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Effects of Weed Trees and Shrubs on Conifers
A Bibliography with Abstracts

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EFFECTS OF WEED TREES AND SHRUBS ON CONIFERS--

A BIBLIOGRAPHY

WITH ABSTRACTS

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SUMMARY OF CONIFER
GROWTH RESPONSE TO BRUSH
AND WEED TREE CONTROL

SECTION	CONIFER SPECIES	TYPE AND METHOD OF CONTROL	GROWTH OR YIELD WITH CONTROL	GROWTH OR YIELD WITHOUT CONTROL	INCREASE[a] (%)	DECREASE[b] (%)	REFERENCE
NORTH	Red pine	Manual release	190 cf/A/y	73 cf/A/y	260	62	Stone 1976
		Manual release - partial	25.4 cords/A	16.8 cords/A	151	34	Buckman and Lundgren 1962
		- full	33.6 cords/A	16.8 cords/A	200	50	
	White pine	Manual release - partial	14.4 cords/A	4.3 cords/A	335	70	Buckman and Lundgren 1962
		- full	32.2 cords/A	4.3 cords/A	749	87	
	Red and white pine	Manual release - partial	22.6 cords/A	14.9 cords/A	152	34	Buckman and Lundgren 1962
		AVERAGE EFFECT (NORTH)			303	56	
SOUTH	Shortleaf pine	Chemical understory - thinned	99 cf/A/y	71 cf/A/y	139	28	Rogers and Brinkman 1965
		- unthinned	81 cf/A/y	58 cf/A/y	140	28	
		Chemical understory - thinned	104 cf/A/y	84 cf/A/y	124	19	Sander and Rogers 1979
		- unthinned	116 cf/A/y	95 cf/A/y	122	18	
	Loblolly-shortleaf pine	Chemical understory	85 cf/A/y	71 cf/A/y	120	16	Grano 1970
			108 cf/A/y	76 cf/A/y	142	30	
	Loblolly-Virginia pine	Manual understory	540 bf/A/y	520 bf/A/y	104	4	Lange 1951
	Loblolly-shortleaf-Virginia pine	Manual-Comercial TSI	20 cf/A/y	11 cf/A/y	182	45	Smalley 1974
		-Commercial repeat	21 cf/A/y	11 cf/A/y	191	48	
		-≥6 in cut	21 cf/A/y	11 cf/A/y	191	48	
		-≥6 in cut repeat	25 cf/A/y	11 cf/A/y	227	56	
		-≥2 in cut	29 cf/A/y	11 cf/A/y	264	62	
		-≥2 in cut repeat	39 cf/A/y	11 cf/A/y	354	72	
		-≥2 in cut, 10 y delay	20 cf/A/y	11 cf/A/y	182	45	
	Southern pines	Chemical TSI	145 cf/A/y	93 cf/A/y	156	36	Starr 1972
	Loblolly pine	Chemical overstory	88 cf/A/y	42 cf/A/y	210	52	Balmer, Utz, and Langdon 1978
		Chemical understory-(BA60)	2390 cf/A	1978 cf/A	121	17	Balmer, Utz, and Langdon 1978
		-(BA80)	2816 cf/A	2351 cf/A	120	16	
		-(BA100)	3037 cf/A	2590 cf/A	117	15	

SECTION	CONIFER SPECIES	TYPE AND METHOD OF CONTROL	GROWTH OR YIELD WITH CONTROL	GROWTH OR YIELD WITHOUT CONTROL	INCREASE[a]	DECREASE[b]	REFERENCE
SOUTH	Loblolly pine	Chemical understory	175 cf/A/y	172 cf/A/y	102	2	Russell 1961
		Manual release	0.559 cf/tree	0.374 cf/tree	149	33	Cain and Mann n.d.
		Chemical release	0.619 cf/tree	0.374 cf/tree	166	40	Cain and Mann n.d.
		Chemical release	546 cf/A	376 cf/A	145	31	Clausen 1978
	Longleaf pine	Aerial release	69 m^3/ha	50 m^3/ha	138	32	Michael 1980
		AVERAGE EFFECT (SOUTH)			170	33	
PACIFIC COAST	Douglas-fir	Chemical release (4.1 lb)	3.24 bf/tree	2.28 bf/tree	142	30	Allan, Beer, and Cousins 1978
		(10.2 lb)	3.96 bf/tree	2.28 bf/tree	174	42	
		(25.5 lb)	3.60 bf/tree	2.28 bf/tree	158	37	
		(41.0 lb)	3.00 bf/tree	2.28 bf/tree	132	24	
		Manual+mechanical release	3.12 bf/tree	2.28 bf/tree	137	27	Allan, Beer, and Cousins 1978
	Ponderosa pine	Chemical+manual understory (1000 tpa)	602 cf/A	654 cf/A	92	+ 9	Barrett 1973
		(500 tpa)	459 cf/A	381 cf/A	120	17	
		(250 tpa)	426 cf/A	291 cf/A	146	32	
		(125 tpa)	403 cf/A	241 cf/A	167	40	
		(62 tpa)	255 cf/A	127 cf/A	201	50	
		Chemical release (6x6f)	611 cf/A	421 cf/A	145	31	Oliver 1979
		(9x9f)	640 cf/A	433 cf/A	148	32	
		(12x12f)	519 cf/A	250 cf/A	208	52	
		(15x15f)	364 cf/A	120 cf/A	303	67	
		(18x18f)	354 cf/A	152 cf/A	233	57	
		AVERAGE EFFECT (PACIFIC COAST)			167	35	
		AVERAGE EFFECT (ALL)			215	41	

[a] % increase = [(with control)/(without control)]x(100)
[b] % decrease = [(with control-without control)/(with control)]x(100)

EFFECTS OF WEED TREES AND SHRUBS ON CONIFERS-- A BIBLIOGRAPHY WITH ABSTRACTS

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NORTH - Red Pine and white pine

Buckman, R. E., and A. L. Lundgren. 1962. Three pine release experiments in northern Minnesota. USDA For. Serv. Stn. Pap. 97, 9 p. Lake States For. Exp. Stn., St. Paul, MN.

Roe, E. I. 1951. Early release from aspen improves yield of pine plantations. USDA For. Serv. Tech. Notes No. 353, 1 p. Lake States For. Exp. Stn., St. Paul, MN.

Three studies were installed in young pine that contained mixtures of apsen and paper birch. Small eastern white pine poles 28-years-old were released from a 36-year-old overstory of aspen and birch at the Squaw Point Road in 1934. Three 1-acre plots were established: (1) all hardwoods cut removing 90 percent of the basal area (full release); (2) only hardwoods overtopping pines cut removing 70 percent of the basal area (moderate release); and (3) no cutting (no release). At the time of release, the full release plot had more white pine trees (315 trees per acre) than the moderate (231) or no release (226) plots. This difference may magnify the contrast between full release and the other two treatements.

The second study was installed in 1931 at Birch Lake to test effects of release on 19-year-old red pine. Three 1/4-acre plots were established: (1) all hardwoods cut removing 58 percent of the basal area in trees over 0.6 in d.b.h. (full release); (2) cutting hardwoods from around only the better pines removing 28 percent of the basal area (moderate release); and no cutting (no release). The stands were roughly comparable before treatment but contrasts between treatments were less than at Squaw Point, probably due to defoliation of aspen by forest tent caterpillars in 1934, 1935, and 1936.

The third study was installed in 1939 in a 35-year-old stand of white and red pine suppressed by an overstory of older aspen and birch near Itasca Park. Two 1/4-acre plots were established: cutting of hardwoods that were completely with, over-topping, or injuring the pine removing 36 percent of the basal area (moderate release) and no release. In addition, densly stocked areas of pine were thinned to a spacing of 6x8 feet on the treated area.

Results 22 years (Squaw Point), 25 years (Birch Lake), or 18 years (Itasca Park) were:

	Squaw Point		Birch Lake		Itasca Park	
Treatment	d.b.h. (in)	Volume growth (cords)	d.b.h. (in)	Volume growth (cords)	d.b.h. (in)	Volume growth (cords)
No release	5.3	4.3	5.9	16.8	--	14.9
moderate release	6.9	14.4	7.8	25.4	--	22.6
full release	8.6	32.2	8.2	33.6	--	--

Board foot volumes are presented graphically for hardwoods and conifers on each plot. Financial aspects are briefly discussed and indicate that release, as done in these experiments, is one of the better investments to be made in forestry.

Earlier results from the Birch Lake red pine plantation were reported in:

Young, L. J. and F. H. Eyre. 1937. Release cuttings in plantations of white and Norway pine. Mich. Acad. Sci., Arts. and Letters Papers 22 (1936):301-320.

Roe, E. I. 1951. Early release from aspen improves yield of pine plantations. USDA For. Serv. Tech. Note 353, 1 p. Lake States For. Exp. Stn., St. Paul, MN.

Jaciw, P. 1972. How silvicides gave 10-year assist to conifer regeneration. Can. For. Ind. 1972:30-36.

Growth and survival of eastern white pine seedlings growing on an area in the Timagami Provincial Forest, Sheppard Township, Ontario Province, was followed for 10 years after release spraying in August 1958. Aerial sprays containing 0.5 lb and 1.5 lb ae of 2,4,5-T or silvex were applied in an oil-in-water emulsion at 2 gal and 4 gal per acre. About 96 percent of the almost 2,000 white pine seedlings per acre were suppressed by mountain maple, hazel, hardwood regeneration (white birch, red maple, pin cherry), and grasses and forbs. In October 1969, 242 white pine seedlings were measured from the August 1958 1-1/2 lb 2,4,5-T 2 and 4 g pa treatments plus controls. Of this total, 47 sample trees had been permanently marked at the time of spraying in the aerial spray plots and 69 seedlings were located in the controls. Results after 10 years were:

	Total Height		Height growth		Suppression class in 1968		
	1958	1968	total	annual	Open	Top suppressed	Side suppressed
	(in)		(in)		(%)		
Control	16.5	52.6	36.1	3.6	8	88	4
Released	7.7	56.1	48.4	4.8	10	29	61

From 1958 to 1968, the average height of released trees increased more than seven times (729 percent) while trees growing in unsprayed brush increased only three times (319 percent). White pine survival 10 years after treatment was 66 percent with rabbit browsing causing most of the mortality. In contrast, animal damage was less on the controls and only 17 percent of the trees died, However, most of the trees were spindly and of low vigor with 16 percent dying from suppression. The greater mortality on sprayed plots was partly compensated by additional recruitment of conifers.

McConkey, Thomas W. 1958. Helicopter spraying with 2,4,5-T to release young white pines. USDA For. Serv. Stn. Pap. 101, 14 p. Northeastern For. Exp. Stn., Upper Darby, PA.

In July of 1954, 2,4,5-T was applied to release two eastern white pine stands on the Massabesic Experimental Forest in southwestern Maine from oak and maple clump sprouts and white birch, gray birch, aspen, and pin cherry seedlings. A 15-acre area of dense hardwoods was treated with 1 lb ae per acre and a 30-acre area of less dense hardwoods was treated with 3 lb ae per acre, both in fuel oil at a volume of 2.5 gal per acre. Pines were not damaged at the lower application rate, but about one-fifth of the seedlings showed some injury on the area treated with 3 lb of 2,4,5-T per acre. To determine effects, growth was measured on 44 tagged trees on the 1-lb area and on 82 trees on the 3-lb area. Total growth in 1956, 2 years after spraying was:

	1 lb ae per acre		3 lb ae per acre	
	Height growth	Diameter growth	Height growth	Diameter growth
	(in)		(in)	
Unreleased	15.9	0.07	9.9	0.06
Released	20.7	0.22	12.4	0.16

Sprayed trees were growing about three times as much in diameter at the base as unreleased pines and were making appreciably better terminal growth.

Ralston, Robert A. 1953. Red pine suppressed for forty years responds to release. USDA For. Serv. Tech. Notes No. 408, 2 p. Lake States For. Exp. Stn., St. Paul, MN.

Three one-half acre plots of 40-year-old overtopped red pine planted under a dense canopy of northern red oak, white oak, and red maple on a average site in the Higgins Lake State Forest were manually released in the spring of 1950. Treatments were: (1) all competing hardwoods removed (complete release); (2) 40 sf of basal area and 166 trees over 3 in dbh left per acre (partial release); and (3) 80 square feet of basal area and 462 trees over 3 in dbh left per acre. Height growth of 50 sample trees in each plot was measured every fall for 3 years after treatment. In order to compare the response to degree of suppression under which the trees grew before release, the trees were grouped into three suppression classes: (A) 17 tallest trees at time of treatment; (B) the next 17 tallest trees; and (C) the 16 shortest trees. Results after 3 growing seasons were:

Treatment	Suppression class	Total height (f)	Average total height growth 1950 --- 1953 (f)
No release	A (9.3f)	10.6	1.3
	B (6.9f)	8.0	1.1
	C (4.3f)	5.1	0.8
	Average	7.9	1.1
Partial release	A (9.9f)	12.2	2.3
	B (6.2f)	8.0	1.8
	C (3.6f)	4.9	1.3
	Average	8.4	1.8
Complete release	A (10.5f)	13.9	3.4
	B (6.6f)	9.6	3.0
	C (3.3f)	5.7	2.4
	Average	9.7	2.9

Response to release was apparent the first growing season and was in direct proportion to the amount of overstory removed. This initial response was reflected mainly by increased needle length and foliage density. By the end of the third season, both completely and partially released trees were far ahead of the unreleased trees. Even the most badly suppressed trees in the completely released plot, which averaged only 3.3 f tall before release, grew three times as much during the fourth growing season as the tallest, least suppressed trees in the control area and almost twice as much as the tallest trees in the partially released plot.

Roe, Eugene I. 1951. Early release from aspen improves yield of pine plantations. USDA For. Serv. Tech. Notes No. 353, 1 p. Lake States For. Exp. Stn., St. Paul, MN.

A 90 acre burn on the Superior National Forest was planted to red pine in 1915 and 1917. In 1931, 15 to 17 years after planting, plots representing two degrees of release from aspen and an untreated check were established. Cordwood volumes were measured on the plots and on a portion of the plantation needing no release was made in 1949. Results 18 years after treatment were:

Treatment	1931			1949			Total stumpage value
	Pine	Aspen	Total	Pine	Aspen	Total	
		(Cords)			(Cords)		($)
No release	1.9	5.9	7.8	16.2	15.6	31.8	40.20
Partial release	2.2	0.6	2.8	20.2	8.0	28.2	44.20
Full release	1.6	0.1	1.7	23.7	2.2	25.9	48.50
No release needed	1.9	0	1.9	32.9	0.3	33.2	65.95

Even a delayed release increased the volume of more valuable pine cordwood. However, the difference was less than it would have been if much of the aspen on the check plot had not been killed by a tent caterpillar edipemic. To obtain the greatest dividends from overtopped plantations, release must be done at an early age.

Shirley, Hardy L. 1941. Restoring conifers to aspen lands in the Lake States. USDA Tech. Bull. No. 763, 36 p. Washington, D.C.

Four plots were treated in 1927 in a 39-year-old aspen stand containing white pine seed trees and a fair stocking of pine seedlings. Aspen was treated as follows: clearcut; 50 percent cut; 30 percent cut; and not cut. Results after 10 years were:

Treatment	Pine seedlings		Average height	
	1927	1936	1930	1936
	(tpa)		(f)	
Uncut	200	40	0.50	0.80
30 percent cut	1320	900	0.44	1.14
50 percent cut	749	579	0.53	0.89
Clearcut	448	149	0.63	1.95

Ten years after cutting, pine seedlings were less numerous than at the beginning and, except where clearcutting and brush cutting had been practiced, still averaged only about 1 ft in height. Aspen did not act as a nurse crop to favor establishment or growth of pine seedlings; instead, it smothered and suppressed them.

In a second study, 25- to 35-year-old white pines 18 ft tall were released from 35 year old aspen and birch in 1931. Release treatments were: (1) uncut; (2) 45 percent cut; and (3) clearcut. Results after 5 years were:

Treatment	Pine trees		Average height		Pine basal area	
	1931	1936	1931	1936	1931	1936
	(tpa)		(f)		(sf/a)	
Uncut	226	175	17.6	20.8	6.85	7.34
45 percent cut	231	206	18.1	21.8	7.67	10.56
Clearcut	315	259	21.3	25.0	14.48	19.37

The pines had grown well the first 10 to 20 years, though not so rapidly as these species grow in pure stands. During the next 10 years, however, height growth averaged less than 6 in per year and progressively declined.

Reduced growth was due to destruction of the leaders by aspen branches. The average tree had had its terminal destroyed three times. The pines immediately thickened their crowns and resumed rapid growth after removal of the apsen in 1931.

In another study, one or two releases applied 2 and 4 years after planting were compared for jack pine and red pine. This test showed that jack pine requires heavier release and will tolerate less shade than red pine. The results after 10 years for two or more replications of 200 trees for each age class of stock were:

Species and class of stock		1 low and 1 high release		1 low release only	
		Survival	Height	Survival	Height
		(%)	(f)	(%)	(f)
Jack pine	1-0	58	9.7	27	8.7
	1-1	77	10.6	50	9.2
	2-0	62	10.4	51	7.3
	average	66	10.2	43	8.4
Red pine	2-0	44	4.2	51	3.4
	2-1	57	5.5	49	4.6
	2-2	70	6.2	66	5.3
	average	57	5.3	55	4.4

Jack pine does best in full sunlight and should be freed from practically all overhead competition within a year after planting. A light uniform cover of aspen or brush, allowing about 80 percent of full sunlight, can be maintained for 1 or 2 years after planting and will release mortality in dought years.

Stone, Douglas M. 1976. Growth of red pine planted on a northern hardwood site. USDA For. Serv. Res. Note NC-210, 4 p. North Central For. Exp. Stn., St. Paul, MN.

Competing hardwoods were removed from a red pine conversion planting by five hand cuttings during the first 10 years after planting 2-1-2 stock. Results after 46 growing seasons:

	Survival	MAI	Merchantable volume
	(%)	(cf/A/y)	(cf/A)
Not released	25	73	3,360
Released	70	190	8,720

Results indicate that merchantable volume production on some well-drained northern hardwood sites could be doubled by intensive management of red pine.

Wendel, G.W. 1971. Converting hardwoods on poor sites to white pine by planting and direct seeding. USDA For. Serv. Res. Pap. NE-188, 19 p. Northeastern For. Exp. Stn., Upper Darby, PA.

Two site-paired plots each of 50-year-old oak near Parsons, West Virginia, were underplanted in 1954 with 3-0 white pine seedlings in three site strata: oak site index 59 (lower-slope), site index 53 (middle slope), and site index 45 (upper-slope). One paired plot was untreated and on the other the overstory was girdled immediately after planting. After four growing seasons, a second release was applied to half of each treated plot. In 1968, after 15 growing seasons, the results were:

	Site Index 59			Site Index 52			Site Index 45		
	Survival (%)	Height (f)	d.b.h. (in)	Survival (%)	Height (f)	d.b.h. (in)	Survival (%)	Height (f)	d.b.h. (in)
No release	88.2	4.4	0.17	91.1	6.1	0.43	90.5	6.4	0.45
One release	80.5	13.3	1.43	96.1	11.7	1.17	93.6	18.8	2.30
Two releases		18.1	2.47		18.2	2.25		19.1	2.49

On similar sites, excellent survival of underplanted pine can be maintained for at least 15 years. After 15 years on areas with an oak site index of about 45, 40 percent of the pines will be free to grow if the overstory is killed at planting time; on areas of oak site index 60, only half as many pines will be in this position. Two releases on the highest quality site equalled the effect of one on the poorest.

-White pine and shortleaf pine

Clements, John R. 1966. Development of a white pine underplantation in thinned and unthinned aspen. For. Chron. 42:244-250.

Thinned and unthinned portions of a 12-year-old aspen sucker stand were underplanted in 1936 with 2-2 eastern white pine stock on the Petawawa Forest, Chalk River, Ontario. By 1950, most seedlings were still small and slow-growing. Mortality among these individuals was high in the following 10 years but mortality was relatively low among seedlings of taller height classes (over 4 feet). Height growth of seedlings continued to be poor so long as the crowns were below the red maple and beaked hazel shrub layer. Data is shown in bar graphs.

White pine planted beneath young aspen stands require care at least until they are 4 feet tall, especially on moist sites where shrub cover is greater. The underneath must be controlled or excessive mortality and poor growth of the survivors will result.

Mowing followed by stump spraying, discing, and basal spraying were effective for shortleaf pine. Where these treatments were used, shortleaf pine grew twice as fast as on untreated areas and fewer planted trees were shaded by brush. Because white pine and white oak are slow starters, the regrowth of brush overtopped them within 5 years. However, these species are tolerant of shade and eventually many grow through the brush cover and overtop it. Nevertheless, until a preplanting treatment can be developed that will completely eliminate the brush for a longer period, these species may benefit more from a release treatment a few years after planting.

-Shortleaf pine and eastern redcedar

Minckler, Leon S. and Russell A Ryker. 1959. Partial conversion of poor hardwood stands to conifers by planting. USDA For. Serv. Tech. Pap. 159, 9 p. Central States For. Exp. Stn., Columbus, Ohio.

Shortleaf pines and eastern redcedar were planted on the Kaskaskia Experimental Forest in southern Illinois: (1) under the canopy of low-quality (oak-hickory) hardwood stands; (2) in openings ranging grom 15 to 120 feet in diameter; and (3) on a 17-acre recently clearcut area. In some stands, openings were deliberately cut to specified diameters (30, 60 and 120 feet) to correspond to half, once and twice the height of the trees. About 4,000 trees were planted under the canopy in 24 different places, about 4,000 were planted in 88 openings, and 15,000 were planted on the 17-acre clearcut. During the first 8 years after planting, all trees planted on the clearcut area and cut openings were released once or twice by cutting competing hardwood brush with an ax.

Mean heights of shortleaf pine and eastern redcedar 8 years after planting are presented in bar graphs. These show that trees grow faster the larger the openings and the less competition from hardwoods. Pine plantations in open fields were 4 times taller, and pine in the clearcut area 3 times taller, than pine in the 30-foot openings. The redcedars in all openings were about 1 foot shorter than pine but their relative response to reduced competition was similar.

Survival in openings cut to specified size 8 years after planting was:

Opening diameter (f)	Survival (%)	
	Shortleaf pine	Eastern redcedar
0	48	30
30	75	41
60	42	52
120	55	46

Results on the clearcut area 8 years after planting were:

Crown competition	Trees per acre		Mean height	
	shortleaf pine	Eastern redcedar	Shortleaf pine	Eastern redcedar
			(f)	
Overtopped	58	45	6.8	2.9
Side Only	135	6	8.5	7.3
None	77	13	11.4	9.5

Site quality had an important effect on the success of stand conversion attempts. Generally, the better the site the faster hardwoods grow in comparison with pine or cedar, and the more difficult and costly conversion becomes. Any conversion to conifers in southern Illinois or similar areas should be confined only to the poorest ridges and uppler slopes.

To convert low-quality hardwood stands having no good growing stock trees to stands of conifers, it is evident from this study that all hardwood competition on the area be killed before planting. For partial conversion, openings at least 1-1/2 to 2 times the height of the overstory trees. The most important lesson learned about releasing conifers from hardwood brush is that the kill must include both the tops and roots, and that release must be soon enough and frequent enough to allow continued vigorous growth of the planted trees. Ax cutting of competition was not an effective release treatment. It is recommended that control of hardwoods in conversion plantings be done by poisoning.

-Shortleaf pine

Brinkman, Kenneth H. and Franklin G. Liming. 1961. Oak and pine reproduction respond to overhead release. J. For. 59(5): 341-346.

Studies were installed beginning in 1938 on the Clark National Forest and in 1936 on the Mark Twain National Forest in typical upland shortleaf pine-oak-hickory stands of the Missouri Ozarks. The stands were underplanted with 1-0 shortleaf pine and various release treatments were then tested on 0.1-acre plots. The stands also contained desirable natural stocking from seedling and sprout pine, oak, and other species. Four degrees and three methods of release were tested on the Clark Forest. Degrees of release were: (1) no release leave 79 f^2 basal area; (2) one-third release, leave 53 f^2; (3) two-thirds release, leave 27 f^2; and (4) complete release. Methods of release were: (1) cut; (2) notch (deep girdle), and (3) peel (shallow) girdle. The same three methods of release plus a no release check were applied to the understory in early March, May, or August on the Mark Twain. Neither method nor season of release had a significant effect on the results and were combined in the analysis. Pine survival 11 years after release was:

	Pine survival			
	Overstory basal area in square feet			
	0	27	53	79
	(%)			
Delayed release by cutting				
Seedlings and sprouts	21	75	43	57
Planted	10	78	92	74
All	13	77	78	72
All other releases combined				
Seedlings and sprouts	57	74	56	62
Planted	78	86	83	72
All	75	82	75	69
All pine				
Seedlings and sprouts	53	74	52	61
Planted	74	83	86	72
All	71	81	76	70

Stoeckeler, J. H. and G. A. Limstrom. 1950. Reforestation research findings in northern Wisconsin and Upper Michigan. USDA For. Serv. Stn. Pap. No. 23, 34 p. Lake States For. Exp. Stn., St. Paul, MN.

Reports results from a series of studies of response of northern conifers to various degrees of manual release on the Nicolet National Forest in Wisconsin. Response of individual species was related to shade tolerance: intolerant species such as jack pine, red pine, and Scotch pine develop poorly under a cover of aspen, paper birch, or other broadleaf trees. Even the more tolerant white pine and Norway spruce suffer reduced survival and growth. White spruce tolerates more cover and may even survive under aspen or birch than in the open.

A number of hardwood and conifer species were planted under a medium cover of aspen (5500 stems per acre) in 1938 and released in 1940. Release treatments included reduction in herbaceous vegetation around each tree and cutting of the aspen-pin cherry overstory at three intensities: 100 percent removal; 80-90 percent removal; and 50 percent removal. Various classes of planting stock were tested with four replications of 200 trees each for each class and a total of 12,800 trees. Results for conifer species after 9 years were:

Species and class of stock	Survival				Height			
	Degree of release				Degree of release			
	100%	80-90%	50%	0%	100%	80-90%	50%	0%
	(%)				(f)			
2-0 Jack pine	88	87	87	36	11.3	9.9	9.1	1.1
2-1 Scotch pine	100	94	86	63	7.7	7.7	6.5	3.6
Red pine	86	78	92	65	6.7	6.1	6.6	4.9
White pine	70	64	57	44	5.1	4.4	5.2	3.8
3-1 Norway spruce	72	62	61	36	2.2	2.2	1.7	1.4
White spruce	91	80	91	86	3.7	3.6	4.5	4.1

Plass, William T., and Alan W. Green. 1963. Preplanting treatments for brushy old fields in southern Illinois. USDA For. Serv. Res. Pap. CS-1, 8 p.

A study to determine effect of several preplanting treatments in short brush (averaging less than 10-ft tall) and tall brush (averaging more than 10 ft in height) types on survival and growth of planted shortleaf pine, white pine, and white oak seedlings was begin in 1955 in southern Illinois. Two replications of 5 treatments and a control were tested in the short brush type: (1) two fall discings; (2) hand cutting all woody plants taller than 4 ft to simulate mowing; (3) hand cutting followed by a stump spray with a mixture of 2,4-D and 2,4,5-T; (4) foliage spray of 2,4-D and 2,4,5-T in water during late summer; and (5) a spring burn. The burn was neither complete nor uniform. Three replications of two treatments and a control were compared on tall brush areas: (1) basal spraying with 2,4-D and 2,4,5-T and (2) a spring burn. Forty seedlings of each species were planted on each plot.

None of the treatments had any effect on survival; survival averaged 60 percent 5 years after planting. Results 5 years after treatment were:

	Height of planted trees		
	Shortleaf pine	White pine	White oak
		(f)	
Short brush areas:			
Untreated	3.9	2.7	2.5
Mow-stump spray	6.2	2.9	2.8
Disc	5.7	3.0	2.5
Mow	5.0	2.8	2.2
Burn	5.0	2.1	2.1
Foliage spray	4.4	2.9	2.3
Tall brush areas:			
Untreated	4.0	2.2	1.6
Basal spray	4.6	2.8	2.0
Burn	3.9	2.0	1.6

The height of trees by degree of shading on the short brush area 5 years after treatment was:

	Not shaded	Partially shaded	Completely shaded
		(f)	
Shortleaf pine	6.5	5.1	3.3
White pine	3.9	3.1	2.3
White oak	2.9	2.9	2.0

Liming, Franklin G. 1946. Response of planted shortleaf pine to overhead release. USDA For. Serv. Tech. Rep. No. 105, 20 p. Central States For. Exp. Stn., Columbus, OH.

Three separate studies involving 78 plots were installed in 1938 and 1939 in Howell and Reynolds Counties, Missouri, to test four methods of release at three seasons, three methods of release of three ages of planted pine, and three methods at four intensities of release to increase survival and growth of 1-0 shortleaf pine planted under oak-hickory stands. The four release methods were: (1) shallow or peel girdle; (2) deep or notch girdle; (3) felling; and (4) no treatment. The five seasons and ages of pine when released were: (1) March - prior to planting; (2) May - 2-1/2 months after planting; (3) August - 5 months after planting; (4) March - 1 year after planting; and (5) March - 2 years after planting. The four degrees of release were: (1) 0 percent (81 sf basal area in overstory); (2) 33 percent (54 sf basal area); (3) 67 percent (27 sf basal area); and (4) 100 percent (0 sf basal area).

Data on survival, height growth, competition by advance hardwood reproduction and new sprouts from treated hardwoods, and damage from falling tops and branches was recorded for 3 or 4 years after release. Tables of shortleaf pine survival and bar graphs of tree height are presented.

The survival of planted pine 3 or 4 years after overhead release averaged about 82 percent and was quite variable. Of the combinations of release treatments tested, only complete release by cutting 1 or 2 years after planting resulted in a significantly lower survival than on the untreated plots.

Survival on untreated plots was as good as on released plots during the first 4 years and appears to be equally good after 8 years.

The great increase in height growth was the most significant effect of overhead release on planted shortleaf pine. Of the combinations of three methods, five ages, and four degrees of release tested, all except these involving a 33 percent release resulted in a significant increase in the height growth of pine compared with those given no release. Response was essentially the same for trees released by cutting, deep girdling, or shallow girdling. Therefore, the method of release can be chosen on the basis of cost, convenience, and utilization of the overstory trees.

As the following 4 year height growth data show, delaying overhead release into and after the first growing season decreased the response but all completely released trees made significantly greater growth than unreleased trees:

	Total height (in)
No release	15.7
March - prior to planting	70.7
May - 2-1/2 months after planting	59.9
August - 5 months after planting	53.5

Height growth after 3 years for delayed release was:

	Total height (in)
March - prior to planting	58.0
March - 1 year after planting	52.1
March - 1 year after planting	48.2

From the stand point of good growth and survival, poine planted in low-value hardwood stands should be released from above as soon as feasible. Release at the time of planting is much better than no release.

As the following data show, height growth for the 4 years after planting increased directly with the degree of overhead release:

Degree of release (%)	Total height (in)
0	16.5
33	19.1
67	32.8
100	64.7

Phares, Robert E. and Franklin G. Liming. 1960. Comparative development of seeded and planted shortleaf pine on a forest site in the Missouri Ozarks. J. For. 58(12):957-959.

Six 0.1-acre plots were installed during 1941 in a pole-size blackjack and post oak stand on the Mark Twain National Forest in Missouri. Overstory trees were removed by clearcutting on three of the plots and by girdling on the other three. In April 1941, seed spots were prepared and 10 filled shortleaf pine seeds were sown in each spot. However, seedlings became established only on about 30 percent of the spots. In April 1942, 1-0 shortleaf pine seedlings were planted in all the vacant seed spots. Both seeded and planted trees were 1-year-old when stocking and height growth comparisons were begun. Height growth for 5 years after release is presented graphically.

Competition from hardwood reproduction influenced height growth of both seeded and planted pine--the more competition, the slower the trees grew. Intensive competition retarded the height growth of seeded trees more than that of planted trees, but the seeded trees still remained taller.

SOUTH - White Pine

Freeman, Phillip C. and D. H. Van Lear. 1977. Performance of eastern white pine and competing vegetation following two methods of stand conversion. Southern J. Appl. For. 1(3):7-9.

A 2x2 split-plot experiment in a randomized complete block design with three replications was installed in a 100-year-old unevenaged stand of upland oaks and hickories with scattered yellow-poplar and shortleaf pine in the Piedmont of South Carolina on the Clemson Experimental Forest. Two conversion methods, clearcutting and planting versus residual overstory with underplanting, were the main treatments. The secondary treatment was control of competing vegetation with foliage and stump sprays of 2,4,5-T. Plots were hand-planted with 2-0 eastern white pine (the study area is near the limits of the range of this species). Diameter and leader growth the season after planting was:

		Diameter (in)	Leader growth (in)
Clearcut	Unsprayed	0.32	8.8
	Sprayed	0.41	9.4
Residual	Unsprayed	0.28	8.3
	Sprayed	0.29	8.4

Analysis of variance showed a significant interaction between overstory and herbicide effect, which was indicative of a positive diameter response to herbicide treatment only in the clearcut. No significant difference in leader growth was detected. Seedling diameters were increased by herbicide treatment in the clearcut but not under the residual overstory. Intensive competition from tall hardwood sprouts in unsprayed clearcut plots apparently inhibited diameter growth of white pine seedlings.

Goebel, N. B. and B. M. Cool. 1968. Releasing white pines after 20 years of suppression in the Upper Piedmont of South Carolina. Forest Farmer 27(12):9-22.

A severely suppressed underplanting of white pine was released from a heavy overstory of oaks, hickories, dogwood, sourwood, and other hardwoods. Results after nine growing seasons:

	No. of trees	Survival (%)	Height growth (f)
Not released	56	64	4.3
Released	57	86	12.1

Sterrett, J.P. and R.E. Adams. 1977. The effect of forest conversion with herbicides on pine (*Pinus spp.*) establishment, soil moisture and understory vegetation. *Weed Sci.* 25(6):521-523.

A study was installed in a mixed oak and black gum stand near Blacksburg, Virginia, to determine the effects of soil-applied fenuron at 5.6 and 11.2 kg/ha and stem-injected 2,4,5-T on pine establishment, soil moisture, and understory vegetation. Treatments were replicated four times in a randomized block design. Plots were planted with 25 2-year-old eastern white pine seedlings 1 year after treatment. Survival 4 months and height 16 months after planting were:

	Survival (%)	Height (cm)
Untreated	88	25
Fenuron - 5.6 kg/ha	88	43
- 11.2 kg/ha	60	41
2,4,5-T	86	43

The poorest survival occurred in plots treated with 11.2 kg/ha fenuron and needles of dying trees showed typical chlorotic symptoms. Since white pine is more shade tolerant than most pines, it is not surprising that unreleased trees survived as well as released trees. The average height difference of 16 to 18 cm between treated and untreated trees was significant.

Wahlenberg, W.G., and W.T. Doolittle. 1950. Reclaiming Appalachian brush lands for economic forest production. J. For. 48(3):170-174.

Quarter- and half-acre test plots in Georgia and North Carolina were established in stands of laurel and rhododendron and planted with eastern white pine. Site treatments included complete grubbing; cutting, piling, and burning of brush; clearing lanes; and clearing spots. Lane and spot clearings were tried both with and without supplemental grubbing of roots. On untreated check plots, white pine failed to produce a stand. Results after 14 years were:

	Survival (%)	Average height (f)
Complete clearing		
cut, pile, burn	64	13.0
cut and grub	54	14.5
Lanes		
clear	58	9.3
cut and grub	60	8.9
Spots		
clear	61	6.7
cut and grub	63	7.8

Hand grubbing was exorbitant in relation to its benefits. Partial clearing followed by planting can be nearly as effective as complete clearing if properly done. Pines should be planted in the center of lanes cleared to a width equal to three-quarters of the height of the shrubs.

-Shortleaf pine

Bower, David R. and Edwin R. Ferguson. 1968. Understory removal improves shortleaf pine growth. J. For. 66(5):421-422.

Twenty 1/10-acre plots were located in a pure stand of shortleaf pine on the Alum Creek Experimental Forest in the Ouachita Mountains of Arkansas. The basal area of the understory averaged about 31 square ft per acre and was composed predominantly of white, post, and red oaks, black gum, hickory, and maple. Plots were selected in groups of four with overstory basal areas of 60, 70, 80, 90 or 100 square ft per acre. One plot in each group was left as a control, and in the spring of 1960, the understories of the others were cut to an average of 18.6, 9.8, and 0 square ft. Hardwoods as small as 0.5 inch in diameter were injected with 2,4,5-T and suppressed pines were felled. Low brush that was too small to inject was left standing and not tallied.

Basal area growth for the 5 years before and after treatment was:

Residual understory basal area	Pine basal area growth			
	Before treatment	After treatment	After/ before	After (adjusted)
(f^2/A)	(f^2/A)	(f^2/A)	(%)	(f^2/A)
32.8	1.900	1.018	53.6	0.962
18.6	1.852	1.139	61.5	1.103
9.8	1.586	1.066	67.2	1.138
0	1.716	1.242	72.4	1.261

Because of the lack of rain during the growing season, all trees grew slower during the study than they had for the previous 5 years. The relationship between present growth as a percent of previous growth and the amount of understory removed was linear--removing 33 square ft of hardwood understory increased the growth of the shortleaf pine overstory by 31 percent. The relationship $G=1.725 - 0.037B + 0.374P$, where G is basal area growth, B is residual understory basal area, and P is basal area growth during the previous 5 years, accounted for 81 percent of the variation in basal area growth.

Elwell, Harry M. 1966. Herbicides for release of shortleaf pine and native grasses. Weeds 14:104-107.

Ten plots were installed to test amine and ester formulations of 2,4,5-T for releasing shortleaf pine from oaks, hickory, winged elm, and other species in southeastern Oklahoma. September and May applications of both formulations were aerially sprayed with 1.5 lbs in 5 gpa of spray according to the following schedule: (1) entire plot in September 1957 or May 1958; (2) 2/3 retreated 1 year later; and (3) 1/3 retreated again 2 years after the initial spray. Diameters of 30 shortleaf pine (60 trees total for two replications) in each size class of seedling, sapling, small pole, and large pole were measured at the beginning of the study and 4 years after the last application of 2,4,5-T (7 years after the initial spray). Results were:

		Diameter increase (1957-64)				
		Seedlings	Saplings	Small pole (in)	Large pole	Average
2,4,5-T ester						
May	0	0.8	1.1	1.3	0.9	1.0
	1.5	1.9	1.3	1.6	1.6	1.6
	1.5 + 1.5	1.0	1.4	2.0	1.8	1.6
	1.5 + 1.5 + 1.5	0.9	1.3	1.9	1.6	1.4
Sept.	0	0.8	1.1	1.3	0.9	1.0
	1.5	0.9	1.7	1.5	1.5	1.4
	1.5 + 1.5	0.9	1.3	1.7	1.6	1.4
	1.5 + 1.5 + 1.5	0.7	1.4	1.9	1.6	1.4
2,4,5-T amine						
May	0	0.9	1.2	1.6	1.7	1.3
	1.5	1.5	2.0	2.4	1.8	1.9
	1.5 + 1.5	1.3	1.9	2.2	2.6	2.0
	1.5 + 1.5 + 1.5	1.4	2.1	2.2	2.2	2.0
Sept.	0	0.9	1.2	1.6	1.7	1.3
	1.5	0.7	1.3	1.9	1.6	1.4
	1.5 + 1.5	1.1	1.5	1.8	1.9	1.6
	1.5 + 1.5 + 1.5	1.1	1.2	1.5	1.6	1.4

Seedlings responded less to treatment than the other size classes, perhaps due to relatively greater herbicide injury. There was a moderately good correlation between defoliation of undesirable hardwoods in 1960 and increased growth compared to the untreated plots. There was little, if any, increase in pine growth from repeated treatments compared to single treatments.

Harrington, T.A. 1958. Release doubles shortleaf seedling growth. USDA For. Serv. South. For. Notes No. 113, p. 3. South. For. Exp. Stn., New Orleans, LA.

Untreated shortleaf pine seedlings on the Cumberland Plateau of Tennessee were released from low-grade hardwoods by girdling and felling with and without spraying with 16 lb aehg 2,4,5-T in diesel oil. First year height growth was:

	Height growth (in)
Untreated	3.4
Girdled and cut	5.8
Girdled, cut, and sprayed	8.3

Harrington, T.A. 1960. Immediate release pays off. USDA For. Serv. South. For. Notes No. 127, p. 2. South. For. Exp. Stn., New Orleans, LA.

Underplanted shortleaf pine seedlings on the Cumberland Plateau in Tennessee were released from overstory hardwoods with one of the following: (1) control; (2) cut small stems and girdle larger stems prior to the first growing season; (3) spray stumps and girdles with 15.4 lb ae 2,4,5-T prior to the first growing season; and (4) silvicide prior to the second growing season. Results for the first two growing seasons were:

	Height growth	
	First year	Second year
	(in)	
Untreated	3.4	3.0
Cut and girdled	5.8	11.8
Sprayed first year	8.3	14.2
Sprayed second year	3.4	6.6

Underplanted shortleaf pine seedlings, released from low-grade hardwoods prior to the first growing season, grew twice as fast the first season and four times as fast the second season as did unreleased seedlings. Approximately 88 percent of all seedlings were living after two seasons regardless of whether or not they were released.

Rogers, Nelson F. and Kenneth A. Brinkman. 1965. Shortleaf pine in Missouri, understory hardwoods retard growth. USDA For. Serv. Res. Pap. CS-15, 9 p. Cent. States For. Exp. Stn., Columbus, OH.

Phares, Robert E. and Nelson F. Rogers. 1968. Seasonal diameter growth in managed shortleaf pine stands in the Missouri Ozarks. J. For. 66(7):563-566.

Hardwood understories in 30-year-old thinned and unthinned stands of shortleaf pine - oak on the Sinkin Experimental Forest in Missouri were left untreated (3 plots each) or were cut and sprayed with 2,4,5-T (3 plots each). Stands were established naturally in 1918; thinning and cutting occurred in 1951 with subsequent foliage spraying in 1952, 1955, and 1959. Results after 10 years were:

	Growth after 10 y (cf/A)	Yield after 10 y (cf/A)	Total yield (cf/A)	Total yield (bf/A)
Unthinned-				
Not released	575	40	3,020	10,350
Released	810	30	3,100	10,985
Thinned-				
Not released	710	545	3,030	11,340
Released	990	780	3,180	11,700

Killing all hardwoods increased volume growth in both thinned and unthinned shortleaf pine stands in Missouri about 40 percent in 10 years. Thinned pine without hardwoods grew nearly 6000 bf/A in the period, about 1700 bf more than where hardwoods were left and about 3500 bf more than unthinned pine where no hardwoods were killed (an increased of 72 percent).

Russell, T. E. 1963. Planted shortleaf responds to prompt release. Tree Planters' Notes 61 (October):13-16.

Russell, T. E. 1969. Underplanting shortleaf pine. Forest Farmer 29(1):10, 17, 18.

Underplanted shortleaf pines on Tennessee's Cumberland Plateau were released from the hardwood overstory by one of the following: (1) untreated check; (2) stems cut or girdled; (3) stems cut or girdled, and sprayed with 2,4,5-T in diesel oil; (4) stems cut or girdled and sprayed with 2,4,5-T in diesel oil 1 year after planting; and (5) stems cut or girdled and sprayed with 2,4,5-T in diesel oil 2 years after planting. Treatments were applied on 0.25-acre plots and replicated four times in randomized blocks. Results after 5 and 10 years were:

	5 years		10 years	
	Survival	Total height	Survival	Total height
	(%)	(f)	(%)	(f)
Untreated	55	1.5	18	3.1
Year of planting-				
no herbicide		4.7	42	11.2
herbicide	67	6.2		15.2
Deferred 1 year-	to		42	
herbicide	78	4.9	to	12.9
Deferred 2 years-			59	
herbicide		3.7		11.4

On the Cumberland Plateau, release can be deferred for at least 2 years, if necessary. But about one year's growth will be lost for each year that seedlings remained overtopped by hardwoods. In the Missouri Ozarks, where summers are dry, delay in release has reduced the response of underplanted shortleaf pine after release.

Sander, Ivan L. and Robert Rogers. 1979. Growth and yield of shortleaf pine in Missouri: 21-year results from a thinning study. Symposium for the management of pines of the interior South, Knoxville, TN, Nov. 7-8, 1978. University of Tennessee. p. 14-27.

Hardwood understories were either left untreated or were controlled with herbicides in a 30-year-old natural longleaf pine stand thinned to 70 square ft of basal area per acre. Plots were thinned again to 70 square ft at age 40 and 51. Results after 21 years were:

	Net periodic MAI for period:			Net periodic yield at age:		
	31-40	41-51	31-51	30	40	50
	(cf/A/y)			(cf/A)		
Unthinned						
Untreated	55	132	95	2,250	3,077	4,523
Treated	68	165	116	2,354	3,038	4,909
Thinned						
Untreated	60	106	84	2,446	3,050	4,213
Treated	83	125	104	2,278	3,105	4,480

At age 51, the difference in net merchantable volume where hardwoods were controlled was 1400 bf per acre on thinned plots and 2500 bf per acre on unthinned plots. Hardwoods reduced growth and yield 8 to 12 percent.

-Loblolly-shortleaf pines and mixed pine stands

Grano, Charles X. 1970. Small hardwoods reduce growth of pine overstory. USDA For. Serv. Res. Pap. SO-55, 9 p. South. For. Exp. Stn., New Orleans, LA.

Grano, Charles X. 1970. Understory hardwoods reduce growth of pine sawtimber. Forest Farmer 29(12):9

Hardwood understories in a 53-year-old loblolly-shortleaf pine stand in Bradley County, Arkansas, and a 47-year-old stand near Crossett, Arkansas, were either left untreated or were cut and sprayed with 2,4,5-T. Results after 14 years (Bradley) or 11 years (Crossett) were:

	MAI after treatment (cf/A/y)	Basal area growth (sf)	Volume growth (cf/A)	Total volumes (cf/A)
Bradley (14 y)				
Untreated	70.6	27.3	989	3,319
Treated	84.9	33.2	1,189	3,517
Crossett (11 y)				
Untreated	75.6	23.1	832	--
Treated	108.2	33.0	1,190	--

In the 14-year study in Bradley County, Arkansas, the total growth advantage attributable to understory control in a 53-year-old stand was 200 cf or 1720 bf. Gross differences in the 11-year study in a 47-year-old stand near Crossett were even more pronounced, totaling 359 cf or 3760 bf per acre.

Lange, Keith D. 1951. Effects of clearcutting understory hardwoods on the growth of a shortleaf-Virginia pine stand. J. For. 49(3):176-178.

Three 1-acre plots were established in an old-field stand of 26-year-old shortleaf and Virginia pines with a heavy hardwood understory near Norris, Tennessee. All hardwoods over 0.5 in. d.b.h. were cut with an axe and suppressed pines were removed on two of the plots; hardwood sprouts were cut again 4 years later. The third plots was left untreated. Results after 11 years were:

	Pine basal area (sf/A)	Pine volume (bf/A)	Volume growth (bf/A/y)
Untreated	97	10,800	520
Treated (2 plots)	95	11,400	540

The 11-year growth of the pine stand was not affected by cutting of the understory. Pine basal area over 0.5 in. d.b.h. increased 35 percent on the treated plots and 32 percent on the untreated plots in 11 years. Merchantible volume increased 107 percent on treated and 113 percent on untreated plots.

Loyd, R. A., A. G. Thayer, and G. L. Lowry. 1978. Pine growth and regeneration following three hardwood control treatments. South. J. Appl. For. 2(1):25-27.

Loblolly pine, longleaf pine, and shortleaf pine response in six southeastern Texas counties was studied after applying one of three hardwood control treatments: (1) injection of all hardwoods over 4-in d.b.h. with 2,4-D amine; (2) mist-blowing understory species with 2 lb ae/A 2,4,5-T in 10 gal; and (3) prescribed burning for control of small hardwoods and seedbed preparation. Most burns were moderately hot but considerable portions of the burning area were not covered. All stands were second-growth pine of site index 80 to 100 that had been managed under selective cutting practices. Twenty sampling points in four stands each of five type-site categories were selected for representative treated and untreated areas (80 points total per treatment). Establishment of regeneration, number of living trees per acre over 0.5-in d.b.h. 3 years after treatment, and radial growth 3 years before and after treatment were measured on each plot. Results were:

	Pine	Hard-wood	Pine regener-ation	Radial growth of 1 to 4 in d.b.h. pines	
		(trees/A)		Before (in)	After
Untreated.	391	821	1151	0.202	0.180
Injection	411	797	2818	0.237	0.359
Mist-blower	244	374	5119	0.282	0.306
Prescribed burn	391	236	4709	0.225	0.261

Untreated areas exhibited a slight decline in radial growth during the second 3-year period while growth increased on all treated areas. The average increase was 59 percent for injection, 16 percent for prescribed burning, and 11 percent for mist-blower. The high post-treatment growth rate of the injection treatment is consistent with the hypothesis that pretreatment suppression had been largely due to the larger hardwoods (above 3.5-in d.b.h.) removed by this treatment. Prescribed burning and 2,4,5-T mist-blower treatment were most effective in promoting new seedling establishment, although this may be offset in some cases by losses of existing small pines.

Mann, William F., Jr. 1951. Profits from release of loblolly and shortleaf pine seedlings. J. For. 49(4):250-253.

Tables and a bar graph show changes in stand development of a 4-year-old loblolly-shortleaf pine stand near Crossett, Arkansas, for 10 years after three intensities of hardwood treatment: all hardwoods 6 in d.b.h. and larger removed; all hardwoods 2 in d.b.h. and larger removed; and all hardwood 5 ft tall or more removed. In all cases, only hardwoods that were overtopping or within 2 ft of overtopping the terminal leader of a pine were removed. Response to release was greatest for the two most intensive treatments.

Muntz, H.H. 1951. Converting scrub oak areas to pine plantations. J. For. 49(10):714-715.

Longleaf, slash, and loblolly pines were planted in a moderately dense stand of shrub blackjack and post oaks in central Louisiana. Some seedlings were released immediately after planting or one and two years later. Seedlings were released by girdling (conventional double hack) of hardwoods or application of ammate into cups or notches at the base of the tree. Two degrees of release were tested: all hardwoods over 0.5 in d.b.h. treated (complete) and all hardwoods over 3.0 in d.b.h. treated (partial). Longleaf pine plantings were destroyed by hogs after the first growing season. Results after 3 years for loblolly and slash pines were:

	Loblolly pine		Slash pine	
	Survival (%)	Average height (f)	Survival (%)	Average height (f)
Time of release				
Not released	33	2.2	27	1.6
Released immediately	86	4.3	46	3.4
Released after 1 y	62	3.2	36	2.3
Released after 2 y	39	2.5	31	2.1
Method of release				
Girdling	93	4.4	40	3.1
Ammate	80	4.2	52	3.7
Intensity of release				
Partial	86	4.3	52	3.0
Complete	85	4.2	40	3.8

Loblolly and slash pine that were released immediately after planting showed much better survival and growth than those not released, or those for which release was delayed. First-year results for longleaf pine were similar: 48 percent survival for trees released immediately and 23 percent for trees that were not released. Method and intensity of release in this study were not important. The average hardwood stand diameter was 4.5 in. so the partial release treatment opened the canopy considerably.

Schmidtling, R. C. 1973. Intensive culture increases growth without affecting wood quality of young southern pines. Can. J. For. Res. 3:565-573.

An experimental plantation of 1-0 slash, loblolly, and longleaf pines from parent trees with high and average specific gravities was established about 20 miles north of Gulfport, Mississippi. The plantation was planted in a split plot design with four replications. Main plots were species, and completely randomized within each main plot were 10 subplots, five cultural treatments applied to the high and average specific gravity offspring. Cultural treatments were: untreated; cultivation only; cultivation plus 1000 lb/acre of 10-5-5 NPK; cultivation plus 2000 lb/acre of 10-5-5 NPK; and cultivation plus 4000 lb/acre of 10-5-5 NPK. Dead seedlings on each plot were replaced at the end of the first growing season.

Cultural treatments strongly affected height, d.b.h. basal area, and volume after 9 growing seasons. Cultivation alone increased height of all species by about 6 ft. Results are presented in graphical form.

Schultz, Robert P. 1975. Intensive culture of southern pines: maximum yields on short rotations. Iowa State J. Res. 49(3) Pt. 2:325-337.

Summarizes results of published and unpublished studies of growth and yield from various intensive cultural practices including mechanical site preparation and weeding.

Smalley, Glendon W. 1974. Development of pine-hardwood stands in north Alabama following improvement cuttings. USDA For. Serv. Res. Pap. SO-100, 9 p. South. For. Exp. Stn., New Orleans. LA.

Mixed oak, hickory, shortleaf pine, Virginia pine, and longleaf pine stands in Jefferson County, Alabama, were treated with three intensities of stand improvement: (1) a commercial improvement cut to remove all merchantable hardwoods (COM); (2) removal by cutting or girdling of all low-value trees > 5.5 in d.b.h. if they were competing with desirable trees (6IN); and (3) removal by cutting or girdling of all undesirable trees > 1.6 in d.b.h. and cutting of trees < 1.6 in if they were overtopping desirable reproduction (2 IN). Uncut check plots (CHK) were also established. Ten and 14 years later, pines were released on one-half of the plots (COMREP, 6INREP, 2INREP) and the third treatment (2IN), which had produced the best response, was applied to one-half of the check plots as a deferred intensive treatment the 10th year (2INDEF). The original study consisted of eight replications of four treatments randomized in four blocks. After the repeat treatments were applied, the design consisted of eight treatments in each of four blocks. Results after 19 years (1948-66) were:

	Stand MAI (cf/A/y)	Pine MAI (cf/A/y)	Stand volume (cf/A)	Pine volume (cf/A)
CHK	11.2	6.9	482	219
COM	20.4	17.8	515	438
COMREP	21.4	19.1	511	473
6IN	21.0	17.4	563	474
6INREP	25.0	23.7	570	539
2IN	29.2	28.0	654	627
2INREP	39.4	37.9	804	775
2INDEF	20.4	18.3	432	428

Volume increment averaged 4 percent on the untreated check during the 19 years, 16 percent on COM plots where only low-value merchantable hardwoods were removed, 22 percent on 6INREP plots which removed culls and undesirable trees > 5.5 in d.b.h., and 65 percent on 2INREP plots where all undesirable trees > 1.5 in d.b.h. were removed.

Starr, John W. 1972. The importance of long term research in forestry. Down to Earth 28(1):30-32.

Two "forties" were established on the Mississippi State University School Forest to assess intensive management in natural upland flatwood pine stands. Growing stock in plots on one "forty" was cut back to 1,500, 3,000, and 4,500 cf per acre and maintained at these levels by periodic cuts at 3-year intervals. All hardwoods were eliminated by injection with 2,4-D amine and basal spraying with 14 lb aehg of 2,4,5-T ester in diesel oil. Reinvading hardwoods were controlled by basal spraying at 3-year intervals. The "natural forty" was not managed and was only protected from fires. Data from two permanent growth pines in each of the 40-acre compartments shows the following after 11 years:

	Basal area			Total volume	
	Pine	Hardwood	Present volume	growth	MAI
	(ft^2/A)		(cf/A)	(cf/A)	(cf/A/y)
Natural forty	107	46	3794	1029	93
Managed forty	93	0	2570	1598[a]	145

[a]Includes 800 cf/A removed in thinnings

Removal of all hardwoods not only favorably effects growth, but seed production of pines and several other variables in a forest stand as well. The "Natural Forty" will revert to the oak-hickory type while the "managed forty" will remain in pine as long as the hardwoods are held in check. About 30 percent of the annual growth (28cf/A/y out of 93 cf/A/y) is in low-grade hardwoods on the "natural forty".

Williston, Hamlin L. and Bernard J. Huckenpahler. 1958. Response of six conifers in north Mississippi underplantings. J. For. 56(2):135-137.

Sixteen plots, each containing six 0.1 acre species subplots, were established on ridge and upper slope stands of blackjack oak, post oak, and hickory (basal area of 64 sf per acre) near Oxford, Mississippi. Each year, for four consecutive years, four randomly selected plots were planted with shortleaf, loblolly, longleaf, slash, and Virginia pine and eastern redcedar. Sixty-four seedlings were planted in each subplot. The overstory hardwoods on half the plots were girdled and poisoned before planting and sprouts cut annually where necessary. Differences in survival and height growth due to year of planting were not significant. Results averaged over planting years after 5 years were:

	Survival		Height	
	Released	Unreleased	Released	Unreleased
	(%)		(f)	
Loblolly pine	56	46	8.0	3.1
Shortleaf pine	54	51	4.9	1.8
Virginia pine	53	60	6.2	2.9
Slash pine	18	20	6.2	2.0
Longleaf pine	10	7	1.1	0.1
Eastern redcedar	66	70	2.6	0.9

Release slightly improved survival of loblolly, shortleaf, and longleaf pine but differences were not significant. Immediate release from hardwood competition, however, resulted in a significant increase in height growth. Seedlings on released plots are almost three times as tall as those on unreleased plots after 5 years.

-Loblolly pine

Balmer, William E., Keith A. Utz, and O. Gordon Langdon. 1978. Financial returns from cultural work in natural loblolly pine stands. South J. Appl. For. 2(4):111-117.

Langdon, O. Gordon and Kenneth B. Trousdell. 1974. Increasing growth and yield of natural loblolly pine by young stand management. In Proc. Symp. on Management of Young Pines. pp. 288-299. USDA For. Serv. Southeastern Area State and Private Forestry, Atlanta, GA.

Yields from ascending levels of cultural treatment of naturally regenerated loblolly pine were compared on 90 areas in Virginia and North Carolina. In the first study, six 37-acre replications of three treatments were compared: (1) control burn before harvest only; (2) control burn before harvest and control of large hardwoods (> 5 in d.b.h.) by chemical frill after harvest; and (3) control burn before harvest, control of large hardwoods by cutting after harvest, and precommercial thinning at age 6. Results on 90 randomly selected plots from site index 95 were:

	Merchantable yield at age:				Average pine	Total
	10	15	20	MAI	d.b.h.	BA
	(cf/A)			(cf/A/y)	(in)	(sf)
Hardwoods not controlled	10	290	848	42	4.8	120
Large hardwoods controlled	70	782	1,776	88	5.7	143
Pine precommercially thinned	120	1,198	2,554	128	6.7	157

Control of large hardwoods doubled pine yields at age 20. Addition of precommercial thinning tripled yields compared with plots where hardwoods were not controlled.

A second study established on 24 plots at age 7 to 8 in four of the precommercially thinned compartments included control of density and all small understory hardwoods by broadcast spray and chemical frill. Results at age 20 were:

Pine BA level	Merchantable yield at age 20			
	Hardwoods not controlled	Hardwoods controlled	Yield increase	Percent increase
(sf)	(cf/A)	(cf/A)	(cf/A)	(%)
60	1,978	2,390	412	21
80	2,351	2,816	465	20
100	2,590	3,037	447	17

Control of large hardwoods alone doubled pine production and increased financial returns more than 200 percent. Additional treatments, such as precommerical thinning and control of small hardwoods, tripled pine production above levels with no treatments and increased financial returns four to six times. The most dramatic increase occurred when the pine component was precommercially thinned and all hardwoods controlled at an early age. This more than doubled the financial returns from all the preceeding steps.

Cain, M. D. and W. F. Mann, Jr. Early growth of planted loblolly pine increased with annual brush control. Unpublished manuscript submitted to South J. Appl. For. Data on file, Alexandria For. Center, South. For. Exp. Stn., Pineville, LA.

Three treatments were applied to newly planted loblolly pine at three locations on gently rolling, moderately drained sites in north Louisiana: (1) untreated check; (2) annual cutting of all hardwoods (cut only); and (3) cutting, grubbing, and herbicide spray (2,4-D amine on stumps and broadcast 2,4-D and 2,4,5-T mixture). A randomized complete block design with three replications at each test area was used. Results after 6 years were:

	Total height (f)	d.b.h. (in)	Volume per tree (cf)
Untreated	15.5	2.51	0.374
Cut only	17.2	3.14	0.559
Cut and spray	17.1	3.25	0.619

Diameters were about 30 percent greater on treated compared with untreated plots after 6 years; volumes were 49 percent higher than on untreated areas. Results imply that one intensive preplant mechanical site preparation may allow planted loblolly pine to become established, but it does not retard hardwood vegetation sufficiently to maximize pine growth.

Clason, T. R. 1978. Removal of hardwood vegetation increases growth and yield of a young loblolly pine stand. South. J. Appl. For. 2(3):96-97.

Four treatments were applied to 1/5-acre plots in a precommercially thinned 7-year-old natural stand of loblolly pine: (1) untreated; (2) hardwoods and grass removed by cutting and spraying with 2,4,5-T and dalapon; (3) hardwood vegetation only removed by cutting and spraying with 2,4,5-T; and (4) herbaceous vegetation only removed by spraying with dalapon. A randomized block design with four replications was used. Results after 5 years were:

	Stocking (trees/A)	d.b.h. (in)	Height (f)	Volume (cf/A)
Untreated	280	2.84	16.9	376
Herbaceous only	320	2.60	15.8	495
Hardwood only	300	2.94	15.6	546
Hardwood and herbaceous	304	3.37	15.9	612

Compared to thinned-only plots, the additive effects of removing hardwood and herbaceous vegetation increased radial growth rates 36 percent and cubic volume growth 63 percent. Removing hardwoods alone accounted for a 23-percent radial growth increase and a 45-percent volume growth increase. Thinning and herbaceous vegetation removal offered no advantage above thinning alone. Optimal increases in growth were obtained when the precommerical thinning included the eradication of hardwoods.

Ferguson, E.R. 1958. Response of planted loblolly pines to reduction of competition. J. For. 56(1):29-32.

Loblolly pine seedlings were planted near Nacogdoches, Texas, during two separate years in a stand of immature shortleaf pine-loblolly pine-hardwoods with a sweetgum and oak understory. These stands contained 237 pine stems with a basal area of 44 square ft and 1,028 hardwood stems with a basal area of 63 square ft per acre. Three treatments were compared for the first year of planting: (1) untreated check; (2) control of hardwoods 1 in. d.b.h. or greater by cutting or girdling and poisoning before planting; (3) clearcutting both hardwoods and pines before planting. These plots were replanted the following year and three sets of new plots were installed before planting: (4) control of hardwoods; (5) clearcutting; and (6) prescribed burning. Height after two or three growing seasons was only shown in bar graphs. Survival was as follows:

	Original planting 1953-54 3 year survival	Replanting 1954-55 2 year survival	Original planting 1954-55 2 year suvival
	(%)	(%)	(%)
1. Untreated	13	64	--
2. Hardwoods controlled (1953)	72	80	--
3. Clearcut (1953)	18	76	--
4. Hardwoods controlled (1954)	--	--	79
5. Clearcut (1954)	--	--	42
6. Prescribed burn (1954)	--	--	49

During dry seasons, first year survival improved with increased intensity of release but there was little effect during a year when rainfall was well-distributed (1955). Release from competition increased height growth--the increase was roughly proportional to degree of release. Seedlings on freshly prepared sites made better height growth than those planted on sites prepared the year before.

Grano, Charles X. 1961. Mortality of loblolly pine planted under small hardwoods. Tree Planters' Notes (October):1-2.

Loblolly pine was planted in 1957 on twelve 1/3-acre plots occupied by small hardwoods in Drew County, Arkansas. Hardwood cover ranged from 25 to 87 percent and dominant stems were 4-to 8-ft in height. Fifty 1-0 pines were planted in each plot. Soil moisture during the first two growing seasons was abundant and the weather was favorable for good survival. Analysis of the relationship between total mortality of pine 24 months after planting and original hardwood cover yielded a correlation coefficient of +0.736, which was significant at the 1-percent level. The relationship was: $y=18.19 + 0.9303x$, where y is percent mortality and x is percent of plot overtopped. The standard error of regression estimate is $\pm$ 2.86 percent.

Hatchell, Glyndon E. 1964. Immediate release needed for maximum growth of seeded loblolly pine. Tree Planters' Notes No. 66 (July):19-22.

Repellent-treated loblolly pine seed was sown in three consecutive years on freshly burned 0.4-acre plots under stands of upland hardwoods near Alexandria, Louisiana. Hardwoods were injected with 2,4,5-T in diesel oil in the spring of the first and second growing season. In a third study, hardwoods were also injected at the time of sowing. Results after 2, 3, or 4 years were:

	Study 1 after 4 years		Study 2 after 3 years		Study 3 after 2 years	
	Survival (%)	Height (in)	Survival (%)	Height (in)	Survival (%)	Height (in)
No release	31	11	33	9	71	4
Immediate release	--	--	--	--	71	15
Release first year	32	60	39	39	61	16
Release second year	35	51	41	25	62	7

Time of release had no significant effect on survival in any of the studies but delaying release for one or two years substantially reduces height growth regardless of site or cover conditions.

Huckenpahler, B.J. 1954. Poisoning versus girdling to release underplanted pines in north Mississippi. J. For. 52(4):266-268.

An 8-year-old underplanted loblolly pine stand was released from overstory blackjack, white, post, red, and black oak, hickories, and black gum (228 trees per acre and 7 in d.b.h. average) in Panola County, Mississippi. Three replications of three treatments were randomly assigned to nine quarter-acre plots containing an average of 628 pines per acre: (1) small hardwoods (0.5 to 3.5 in. d.b.h.) felled and stumps treated with ammate, large hardwoods treated by the ammate crystal-in-notch method; (2) small hardwoods felled and large hardwoods girdled; and (3) untreated. Results after 2 years were:

	D.b.h. increase (in)	Height increase (f)	Basal area increase (sf/A)
Average all pines:			
Unreleased	0.6	4.0	5.5
Released by poisoning	1.0	5.2	11.2
Released by girdling	1.1	6.1	15.8
100 tallest pines per acre:			
Unreleased	0.7	5.5	1.8
Released by poisoning	1.3	5.9	3.6
Released by girdling	1.5	7.2	4.9

Single-hack frill girdling gave a more complete crown kill on an upland oaks and hickories and cost less, but was slower in killing than ammate poisoning. However, ammate poisoning was more effective in preventing sprouting although the pines were large enough to withstand competition from sprouts. Diameter, height, and basal area growth of released trees were significantly greater than that of unreleased trees. Diameter growth and basal area growth was about twice and height growth about 1 1/2 times that of unreleased trees. Differences between release by poisoning and girdling were not significant. Almost one-tenth of the underplanted pines were killed or severely damaged by falling debris from deadened overstory trees. This heavy damage is believed to be largely due to the 8-year delay in release.

Korstian, C.F. and M. Victor Bilan. 1957. Some further evidence of competition between loblolly pine and associated hardwoods. J. For. 55(11):821-822.

Sixty 7-year-old loblolly pine seedlings were selected from an even-aged stand of loblolly pine and hardwoods on an upland site of the Duke Forest in the North Carolina Piedmont Plateau. Twenty pines were randomly selected for each of the following treatments: (1) crown and root competition reduced by killing all woody plants within 33 in of the pines with ammate; (2) crown competition reduced by tying back all woody plants capable of shading the pine; and (3) no treatment. Analysis after two growing seasons showed that released trees grew faster than unreleased trees but that there was no difference between release treatments. Therefore, all woody plants within 12.5 ft of the pines in treatment 1 were killed with ammate for the final 2 years of study. Results 4 years after the initial treatment were:

	Adjusted mean growth	
	Height growth (in)	Diameter growth 1 in. above ground (in)
Untreated	60.9	0.94
Hardwoods poisoned	98.7	2.34
Hardwoods tied back	84.5	1.67

Treatment means were adjusted for pretreatment differences. Both height and diameter growth of released pines were significantly greater than that of unreleased pines. Further, trees released by poisoning grew faster than those released by tying the hardwoods back.

McClay, T.A. 1955. Loblolly pine growth as affected by removal of understory hardwoods and shrubs. USDA For. Serv. Res. Note No. 73, 2 p. Southeast. For. Exp. Stn., Asheville, NC.

Three treatments that resulted in elimination or annual removal of the understory in a loblolly pine stand were tested in the Santee Experimental Forest near Charleston, South Carolina: annual summer burning that reduced size and vigor of understory sprouts, annual winter burning that had little effect on sprout vigor, and annual summer foliage spraying after an initial burn that eliminated the understory in a few years. Each treatment, and control, consisted of three replicated 1/4-acre plots in a randomized block design in an even-aged 40- to 50-year-old pine stand with a site index of 85 and basal area of 90 square ft. Results 5 years after treatment were:

	Average d.b.h. (in)	Average radial growth (in)
Control	12.7	0.36
Annual foliage spray	12.7	0.37
Annual summer fire	12.6	0.35
Annual winter fire	12.3	0.38

Radial growth of trees 7- to 17-inches in diameter on the control plots, where understory hardwoods were left undisturbed, was equal to that on areas where the understory had been eliminated or removed annually.

Miller, William D. 1961. Development of planted loblolly pine in a poisoned hardwood stand of the lower Piedmont. J. For. 59(3):184-186.

Sixty 1/40-acre subplots were established in a randomized design with four replications of 12 treatments and three checks on the Hill Demonstration Forest, Durham County, North Carolina. The twelve treatments consisted of two herbicides (2,4,5-T and a mixture of one-third 2,4,5-T and two-thirds 2,4-D) applied as basal or stump sprays at 1, 2, and 4 percent ae by weight in kerosene to hardwoods less than 3.5 in d.b.h. Check treatments included cutting without spraying, cutting and spraying with kerosene, and basal spraying with kerosene. Hardwoods larger than 3.5 in d.b.h were treated with ammate in notches. All plots were planted with 36 1-0 loblolly pine seedlings but only the 25 interior trees in each plot were measured to avoid edge effects. Survival after 5 years and growth after 9 years were:

	Survival	Average height	D.b.h., basal area, and height of pines at least 9.5 f high		
			D.b.h.	B.A.	Height
	(%)	(f)	(in.)	(sf/A)	(f)
Check	41	11.0	1.6	4.38	12.2
Stump spray					
2,4,5-T	62	15.6	2.2	14.80	15.6
Mixture	65	13.8	1.9	11.48	14.0
Basal spray					
2,4,5-T	62	12.9	1.8	10.68	13.3
Mixture	54	13.4	1.9	10.19	14.0

Heights of pines on treated plots were significantly greater than heights on check plots, but differences between release treatments were not significant. A volume index (basal area x height) shows a 3-to-1 superiority for release treatments.

Miller, William D. and Oscar C. Tissue. 1956. Results of several methods of release of understory loblolly pine in upland hardwood stands. J. For. 54(3):188-189.

Ten one-acre plots were established in an oak-hickory stand on the Hope Valley Forest in Chatham County, North Carolina. Two replications of five treatments were installed to release a loblolly pine understory of 1,040 to 2,590 trees per acre ranging in age from 2- to 15-years. Treatments were: (1) untreated; (2) merchantable hardwood fuelwood cut (CH); (3) same as (CH) plus cutting of all hardwoods below 3.6 in d.b.h. (CBH); (4) poison all hardwoods 3.6 in d.b.h. and larger with ammate in notches (AH); and (5) same as (AH) plus cutting all hardwoods and brush below 3.6 in d.b.h. Periodic growth for about two growing seasons after treatment (between June 1952 and April 1954) was:

	Height growth (f)	D.b.h. growth (in)
Untreated	0.4	0.09
CH	0.8	0.32
CHB	0.6	0.42
AH	0.8	0.39
AHB	0.8	0.39
All release treatments	0.8	0.38

Height growth of pines up to 9 ft tall at time of treatment was doubled as a result of release; diameter growth was quadrupled. There was little difference between release treatments but felling caused more damage to young pines than did treatments with ammate. Felling was also four to five times more expensive than poisoning but some of this cost can be recovered if the cut material was sold for fuelwood. The removal of brush had little effect on growth.

Russell, T. E. 1961. Control of understory hardwoods fails to speed growth of pole-size loblolly. USDA For. Serv. South. For. Notes No. 131, pp. 3-4. South. For. Exp. Stn., New Orleans, LA.

A study was installed in a 26-year-old loblolly pine plantation near Alexandria, Louisiana, on a site with a site index of 90 ft. When the study began in May of 1954, the pines were thinned from 120- to 90-square ft of basal area (2800 to 2100 cu ft) per acre and the 3800 hardwoods per acre were treated with ammate on one-half of each plot. New sprouts or seedlings were killed each year thereafter. Results during a 6-year period (1954-1959) after treatment were:

	Total growth (cf/A)	MAI (cf/A/y)	Height growth (f/y)	Diameter growth (in)
Untreated	1034	172	1.4	13.2
Treated	1049	175	1.4	13.3

Complete elimination of understory hardwoods in a 26-year-old pole-size loblolly pine stand near Alexandria, Louisiana, has not significantly improved growth.

Russell, T. E. 1971. Silvicides help to establish pine in southern hardwoods. Forest Farmer 30(9):8, 16, 17.

Six treatments plus an untreated check were installed on 0.25-acre plots of loblolly pine planted under an oak-hickory stand near Sewanee, Tennesse. The most intensive treatment consisted of girdling hardwoods 4 in d.b.h. and over, cutting smaller trees, and spraying girdles or stumps with 2,4,5-T in diesel. Partial release was obtained by cutting either overstory or understory hardwoods and applying silvicide. Each degree of hardwood control was also tested without silvicide. The study was installed in a randomized block design with four replications. Results after 10 years were:

	Survival (%)	Height (f)
Untreated	35	4.0
Overstory cut and sprayed	39	10.0
Overstory cut only	15	21.2
Understory cut and sprayed	94	18.2
Understory cut only	69	9.0
Overstory and understory cut and sprayed	86	26.0

Existing hardwoods should be controlled thoroughly when underplanting on Tennessee's Cumberland Plateau. Removing only the larger overstory trees will not release pines sufficiently for satisfactory survival or growth on most cutover sites. Moreover, merely cutting overstory hardwoods in the year of planting is futile unless a silvicide is applied to reduce sprouting. Deferring overstory removal reduced height growth less than 1 ft for each year that pines were suppressed.

Similar results in northern Alabama suggest that a silvicide must be used throughout the region for adequate control of small hardwoods. Although pines can be released by repeatedly cutting small hardwood stems, such treatment is seldom feasible.

Shoulders, Eugene. 1955. Release underplanted loblolly early. USDA For. Serv. South. For. Notes No. 100, p. 2-3. South. For. Exp. Stn., New Orleans, LA.

Loblolly pine planted in central Louisiana under a hardwood stand consisting of 330 stems per acre of blackjack and post oak was released at planting or 1 and 2 years after planting. Double hack girdles or ammate applied to notches cut in the trunk at groundline were equally effective. Results at plantation age 7 were:

	Survival (%)	Total height (ft)
Unreleased	46	9.5
Released at planting	82	16.0
Released after one season	46	14.5
Released after three seasons	46	13.0

Complete release (removal of all hardwoods over 0.4 in d.b.h.) did not give better pine survival and growth than did partial release (removal of hardwoods more than 3 in d.b.h.). Immediate release is needed for best survival and growth of underplanted loblolly pine seedlings.

Smalley, Glendon W. 1956. Girdle or fell oaks to release pines? USDA For. Serv. South. For. Notes No. 122, p. 2. South. For. Exp. Stn., New Orleans, LA.

Loblolly pines planted in February 1959 under southern red oak near Birmingham, Alabama, were left unreleased or were released either by girdling or felling the oaks. Ammate was applied to all girdles or stumps to reduce resprouting. Results after 3 years were:

	Survival (%)	Total height (ft)
Unreleased	27	1.7
Girdled	91	7.5
Felled	94	7.7

Shipman, Robert D. 1954. Release of loblolly pine by various weeding methods. USDA For. Serv. Res. Notes No. 65, 2 p. Southeast. For. Exp. Stn., Asheville, NC.

Shipman, Robert D. 1954. Pine released by various weeding methods. South. Lumberman 189(2369):125-126.

A weeding study was conducted on 1/40-acre plots of 3-year-old natural loblolly pine seedlings averaging 2 1/2 ft tall on the Santee Experimental Forest near Charleston, South Carolina. Several control treatments using one part 2,4,5-T in 29 parts of kerosene were compared with the conventional method of cutting back competitors with a machete. All plots were thinned to 40 pines overtopped by 3- to 12-ft high competing hardwoods and brush. Results after four growing seasons were:

	Relative cost	Seedlings free to grow	Average total height
	(%)	(%)	(ft)
Untreated	0	22	4.9
Hand cut, no herbicide	100	71	6.7
No cutting, basal spray	124	80	7.2
No cutting, brush herbicide on stems	188	70	7.6
Hand cut and spray stumps	194	97	8.8

Hand cutting alone produced a satisfactory degree of release at half the cost of complete release. There is no need for a second weeding, and the cost of chemical does not appear justified in terms of increased survival and growth of released loblolly pine seedlings. Only about one out of five overtopped seedlings were able to outgrow the brush without some form of release treatment.

Shipman, Robert D. 1954. Release of loblolly pine by various weeding methods. USDA For. Serv. Res. Notes No. 65, 2 p. Southeast. For. Exp. Stn., Asheville, NC.

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Williston, Hamlin L. and Bernard J. Huckenpahler. 1957. Hardwood underplanting in north Mississippi. J. For. 55(4):287-290.

For three successive years, four replications each of 25 trees were underplanted with white ash, white oak, yellow-poplar, black locust, black walnut, and loblolly pine on upper, middle, and lower slopes, and on minor bottoms near Oxford, Mississippi. The overstory on half of three plots was killed by girdling and poisoning immediately before planting. Where necessary, sprouts and other competing vegetation were cut back annually. Loblolly pine, black locust and yellow-poplar plantings usually kept ahead of competition after two releases. Results for loblolly pine after 5 years were:

	Survival		Average Height	
	Released	Unreleased	Released	Unreleased
	(%)		(f)	
Upper slope	72	46	8.4	2.3
Middle slope	76	34	7.5	1.4
Lower slope	72	41	8.2	1.8
Minor bottom	35	7	8.4	1.2

Survival and height growth were significantly increased by release. Of the six species tested, loblolly pine was the most suitable for underplanting in rehabilitating the upland hardwood type in north Mississippi. Immediate release of all underplantings is needed to obtain satisfactory survival and height growth.

Yocum, H.A. 1962. More than one treatment may be needed to release underplanted pines. USDA For. Serv. South. For. Notes 140, p. 4 South. For. Exp. Stn., New Orleans, LA.

Loblolly pines were underplanted in two studies in northern Alabama on sites fully occupied by young upland hardwoods. Best results were obtained by cutting or girdling all hardwoods over 5-ft tall or more than 1.6 in d.b.h. Hardwoods were treated at the time of planting, no silvicides were used, and there were no follow-up treatments.

Pine survival after 12 years in one test averaged less than 50 percent and more than half were overtopped. For the other test, survival was 67 percent after 6 years and about 1/6 of the pines were overtopped. Both studies strongly suggest that, where young hardwoods dominate a proposed planting site, control prescriptions should provide for repeat treatments or for initial treatment with silvicides.

-Longleaf pine

Michael, J. L. 1980. Long-term impact of aerial application of 2,4,5-T to longleaf pine (Pinus palustris). Manuscript accepted for Weed Science, on file. G. W. Andrews For. Sci. Lab., USDA For. Serv., South. For. Exp. Stn., Auburn, AL.

A study was established in 1959 on 10 acre plots of longleaf pine shelterwoods near Brewton, Alabama, to compare aerial sprays of 2 lb ae per acre of 2,4,5-T as ester, acid, and amine formulations. In 1979, volumes were measured on 15 check and 15 ester treated plots (5 subplots in each of 3 blocks per treatment) using a 100 percent inventory. The results after 20 years were:

	Total trees (trees/ha)	Merchantable trees (trees/ha)	Height (m)	Merchantable volume (m^3/ha)
Untreated	2471	815	8.33	49.65
Released	2473	1012	9.78	69.39

Merchantible tree volumes were 40 percent greater on treated than on untreated plots; this is an 8y growth advantage.

PACIFIC COAST - Coast redwood

Boe, Kenneth N. 1971. Growth of released redwood crop seedlings on the Redwood Experimental Forest. USDA For. Serv. Res. Note PSW-229, 5 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, CA.

Potential redwood crop trees, 3- to 4-years old, were released from shrub and grass competition. The release distances tested were radii of 2, 3, and 4 ft; the methods used were basal or foliage spraying with 2,4,5-T and 2,4-D mix and hoeing-cutting. Three replications, each containing ten trees, were arranged in a randomized block design.

For the first 3 years, released seedlings (except those released by cutting) grew faster than untreated seedlings. By the end of the fourth growing season, when competing vegetation had already reoccupied the weeded areas, height growth of all seedlings appeared to be equalizing. This age-class of redwood crop seedling (vigorous, healthy, and tallest at a specific minimum spacing) may not need weeding-release for satisfactory growth in environments similar to that where tested.

Fritz, Emanuel and James A. Rydelius. 1966. Redwood reforestation problems. An experimental approach to their solution. Found. Amer. Res. Manage. 130 p. Response of suppressed redwood and Douglas-fir seedlings after release from over-topping brush. pp. 97-104.

Suppressed 16- to 19-year-old redwood and Douglas-fir seedlings under a canopy of blue blossom ceanothus, tanoak, and madrone were released on a 1/4-acre square plot located in a 23-year-old Site III clearcut, 12 miles east of Fort Bragg, California. In April 1962, all hardwood stems greater than 1 in d.b.h. on half the plot were frilled and basal sprayed with 2-2/3 lb ae 2,4-D and 1-1/3 lb ae 2,4,5-T (Weedone Brush Killer 64) in 25 gal diesel oil while on the other half, all hardwood stems were basal sprayed only. In August 1963, remaining live stems over the entire plot were frilled and treated with ammate at 7 lb per gal of water. Most of the brush was dead or dying by the end of the year.

A total of 148 redwood and 428 Douglas-fir seedlings ranging in height from less than 3 in to more than 18 ft were found on the plot. The majority of redwoods were in the lower and medium height classes (up to 5 ft) while Douglas-firs were more uniformly distributed. The smaller seedlings of both species were generally spindly and relatively sparsely needled; most were making no measurable height growth and only limited lateral extension of branches. Yearly height growth measurements for each seedling between 1961 and 1965 were taken. Growth rate of almost all redwood and on Douglas-firs less than 3-ft tall increased the first growing season. Height growth of taller Douglas-firs initially declined. Growth rates for both species increased in succeeding years with taller trees responding less to release than shorter trees. Falling dead brush caused retarded height growth and affected redwood and shorter Douglas-firs (less than 3-ft tall) to a greater extent.

The mortality due to falling brush and the height growth response in 1961 (before release) and for 5 years after release were:

Height class	Mortality	Average Height Growth					Ratio 1965/ 1961
		1961	1962	1963	1964	1965	
(f)	(%)	- - - - - - - - - - (in) - - - - - - - - - -					
		REDWOOD					
Up to 1.0	30	1.18	1.82	4.02	3.71	3.73	3.2
1.1-2.0	10	1.41	2.03	3.67	2.76	2.73	1.9
2.1-2.0	9	3.10	3.52	5.96	3.34	4.50	1.4
3.1-5.0	0	4.34	4.68	7.35	5.73	7.74	1.8
5.1-10.0	0	5.72	7.80	10.30	9.92	7.88	1.4

DOUGLAS-FIR

Up to 1.0	40	0.98	1.24	2.28	3.47	4.24	4.3
1.1-2.0	41	1.11	1.32	2.82	3.38	4.25	3.8
2.1-3.0	10	2.18	2.63	5.44	8.85	9.78	4.5
3.1-5.0	7	3.70	2.50	6.60	9.41	10.40	2.8
5.1-10.0	10	5.69	4.57	6.02	8.19	6.73	1.2

The study provides promising evidence of accelerated height growth for both redwood and Douglas-fir seedlings when released from dominating hardwood brush. The impact of falling dead brush suggests, however, that chemical treatments be undertaken before brush attains large sizes but after conifer seedlings have become established.

Douglas-fir

Allan, G. G., J. W. Beer and M. J. Cousin. 1978. Growth enhancement of a juvenile conifer forest six years after application of a controlled release herbicide. Intern. Pest. Control 20:_____.

Six treatments were applied to release Douglas-fir seedlings from decidious brush and herbaceous vegetation in a plantation near Sedro Woolley, Washington. A controlled release formulation of 2,4-DB chemically bonded to Douglas-fir bark was applied at 0, 200, 500, 1250, and 2000 g to a 2.5 ft^2 area around each tree. This corresponded to application levels of 0, 4.1, 10.2, 25.5, and 41 lb ae/A for a planting density of 250 trees/A and a treatment area of 2.5 ft^2. A equal area around another set of trees was hand weeded and covered with black plastic. One third of the original seedlings were eliminated from statistical comparisons due to deer browsing and insect damage. Measurements were based on between 18 and 36 seedlings per treatment. Results 6 years after treatment were:

Treatment	Equivalent rate (lb/A)	Height (cm)	Basal area at d.b.h. (cm^2)	Stem volume (bf/tree)
Untreated	0	472	17.5	2.28
200 g 2,4-DB	4.1	528	23.7	3.24
500 g 2,4-DB	10.2	544	28.5	3.96
1250 g 2,4-DB	25.5	513	27.1	3.60
2000 g 2,4-DB	41.0	499	22.6	3.00
Plastic mulch	---	498	23.2	3.12

The most effective level of 2,4-DB tested, 500 g/tree, increased tree height growth by more than 15 percent and stemwood volume of 74 percent compared with untreated seedlings.

Gratkowski, H. 1979. Growth of Douglas-fir after release from snowbrush ceanothus. Unpublished, manuscript in preparation. Data on file, For. Sci. Lab., USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Corvallis, OR.

Height and diameter growth of young Douglas-firs following three degrees of release from snowbrush were followed for 5 years on five clearcut areas on the west slope of the Cascade Range in Oregon. One study area on the Umpqua National Forest was measured for 10 years following treatment. Release treatments were: (1) snowbrush lopped and removed and stumps sprayed with 2,4,5-T (complete release); (2) snowbrush lopped and allowed to resprout (lopped); and (3) snowbrush basal sprayed with 2,4,5-T (basal spray). Results after 5 years are shown in Table 1.

Release from snowbrush ceanothus did not increase total height growth during the first 5 years after treatment; released trees were no more than 1-ft taller than trees in undisturbed snowbrush. A year-by-year analysis showed that annual rates of height growth were about equal for 1 or 2 years after release. Then, however, growth of released trees exceeded that of trees in snowbrush and this difference increased each succeeding year. The unreplicated 10-year results suggest that this trend continues throught the second 5-year period. In fact, released trees were significantly taller than unreleased trees at the end of 10 years. Growth of Douglas-firs that were 2-ft tall at time of treatment was 1.7 to 2.8 times the growth of similar trees that were not released. Trees 8-ft tall at time of release grew only 1.2 to 1.4 times than of similar trees in mature ceanothus. This indicates that release has a cumulative beneficial effect resulting in greater average annual growth each year for at least 10 years after treatment.

In contrast to height growth, diameter growth response to release occurred during the first 5 years. Release was most beneficial for the smallest trees heavily shaded beneath snowbrush; diameter growth of trees 2-ft tall when released was 1-3/4 to 3 times more than that of similar trees that were not released. Although brush control was less effective for trees with tops emerging above the brush canopy, even trees 8- to 10-ft tall increased diameter growth by 13 to 31 percent. The unreplicated 10 year results suggest that the initial diameter response continues for at least 10 years.

Gratkowski, H., and P. Lauterbach. 1974.. Releasing Douglas-fir from varnishleaf ceanothus. J. For. 72(3):150-152.

Growth of young Douglas-firs released from varnishleaf ceanothus was measured for 5 years on two sites in the Cascade Range of Oregon. One site was aerially sprayed with 2 lb ae per acre 2,4,5-T when shrubs were about 6-ft tall and conifers were 1/2 to 7 ft; 93 trees in the sprayed and 85 trees in the unsprayed plots were measured. Small plots of 10 ft tall varnishleaf were treated with one of three treatments on the second site: (1) no treatment; (2) ceanothus lopped and sprayed with 2,4,5-T (complete release); and (3) ceanothus basal sprayed with 2,4,5-T (basal spray). Twenty-five trees were measured on each plot. Results after 5 years were:

	Height of trees when released (f)					
	1	2	3	4	5	6
	height growth (%)					
None	100	100	100	100	100	100
Complete release	185	185	183	184	184	185
Basal spray	130	136	140	144	147	149
Aerial spray	255	217	200	188	181	171

Aerial spraying effectively released Douglas-firs, and their growth was 1.7 to 2.5 times that of comparable trees under unsprayed ceanothus. Response on basal spray plots was similar but less dramatic. The data suggest that release will save about 8 years in growing 2-ft tall trees to a height of 20 ft.

Groundwork, Inc. 1978. Preliminary report: Willamette herbicides study project. Forest Workers Research Team, Groundwork, Inc., Eugene, Oregon. Unpublished report, September 12, 1978.

Results of a survey from five clearcut units on the Willamette National Forest on the west slope of the Cascade Mountains in Oregon were summarized. A systematic random sample of 1/100-acre plots, one plot per acre, was used to measure conifer height, leader growth, first and second whorl growth, age, species, condition, and position in relation to competing vegetation. One cutting had been sprayed the year of sampling and the other four were scheduled for spraying to release the conifers, mostly Douglas-firs, from vine maple, ceanothus, and associated brush species.

Although the data was not analyzed statistically, the study concludes that: (1) the majority of crop trees were vigorous even when growing in the presence of brush; (2) release sprays may damage the conifers; (3) trees growing at the edge of the ceanothus crown grow faster than similar aged trees growing in the open; and (4) overtopped trees are not necessarily supressed since many are vigorous. However, trees growing in the open or under the brush were not necessarily adjacent. Further, the response to release has not yet been measured.

Lauterbach, P. G. 1967. Chemical weeding and release of conifers in western Oregon and Washington. IN: Proc., Herbicides and vegetation management. Sch. For., Oreg. State Univ., Corvallis, OR. pp. 148-151.

Plots were established to follow response of Douglas-firs to release from red alder and associated brush on two operational aerial spray areas in western Washington. The Toledo Cutoff area was sprayed with phenoxy herbicides on June 10, 1957, and the Doty-Dryad area was sprayed in mid July of 1956. Both areas are estimated to be Site Class II for Douglas-fir. Results after 5 or 6 years were:

Toledo Cutoff

Height class	Treatment	No. of trees	Initial height	5 year growth	Growth in relation to unsprayed trees
(f)			(f)	(f)	(%)
2	Unsprayed	--	--	--	
	Sprayed	--	--	--	--
5	Unsprayed	9	5.7	4.4	
	Sprayed	36	5.0	9.6	118
10	Unsprayed	15	9.3	4.8	
	Sprayed	19	9.3	10.8	125
15	Unsprayed	5	13.8	6.3	
	Sprayed	5	13.8	12.1	92
20	Unsprayed	1	20.0	8.0	--
	Sprayed	--	--	--	--
Ave.	Unsprayed	30	9.3	5.1	
	Sprayed	60	7.3	10.2	100

Doty-Dryad

Height class	Treatment	No. of trees	Initial height	5 year growth	Growth in relation to unsprayed trees
(ft)			(ft)	(ft)	(%)
2	Unsprayed	3	2.0	8.4	
	Sprayed	5	2.2	9.8	17
5	Unsprayed	19	4.4	6.8	
	Sprayed	22	5.4	10.8	59
10	Unsprayed	9	9.2	9.2	
	Sprayed	7	9.8	12.3	34
15	Unsprayed	--	--	--	
	Sprayed	2	14.2	12.0	--
20	Unsprayed	--	--	--	
	Sprayed	1	19.0	11.2	--
Ave.	Unsprayed	31	5.8	7.8	
	Sprayed	37	6.6	11.0	41

Initial terminal damage appeared to be greater following the June spraying but the trees grew considerably faster than trees sprayed in July during the year after release. In fact, trees sprayed in mid-July did not grow faster than unsprayed trees until the third year. Released trees had longer needles and more dense, darker green foliage than trees growing in the shade of alder. Diameter of released trees was two to two and one-half times that of unreleased trees of the same height at the time of spraying.

Miller, Richard E. and Marshall D. Murray. 1978. The effects of red alder on growth of Douglas-fir. In Utilization and management of alder. USDA For. Serv. Gen. Tech. Rep. PNW-70. Pac. Northwest For. and Range Exp. Stn., Portland, OR pp. 283-306.

Berntsen, Carl M. 1961. Growth and development of red alder compared with conifers in 30-year-old stands. USDA For. Ser. Res. Pap. PNW-38, 20 p. Pac. Northwest For. and Range Exp. Stn., Portland, OR.

Tarrant, Robert F. 1961. Stand development and soil fertility in a Douglas-fir--red alder plantation. For. Sci. 7(3): 238-246.

The long-term effects of off-site red alder that were interplanted in 1933 within a 4-year-old Douglas-fir plantation in southwest Washington (Wind River Experimental Forest) are described. Insufficient available nitrogen limits tree growth in this plantation. Red alder clearly increased height and diameter of the associated dominant Douglas-fir. Improved growth in diameter began when the Douglas-fir emerged through the alder canopy. This emergence occurred at about 30 years from seed at Wind River and in several even-aged, mixed stands that were also investigated. By age 48, Douglas-fir volume per acre in the mixed stand averaged 3100 cf compared to 2900 cf in the pure stand. Red alder volume was about 2500 cf. Maintaining red alder in Douglas-fir stands can increase merchantible yields on nitrogen-deficient sites. Controlling stand density at an early age is necessary to maintain both Douglas-fir and alder in a dominant or codominant position. To provide adequate nitrogen and not seriously reduce Douglas-fir growing stock, about 20 to 40 uniformly distributed red alder per acre should be retained.

In the even-aged stands near Cascade Head, Oregon, and Delezene and Skykomish, Washington, high initial densities of even-aged red alder reduced survival of Douglas-fir. An adequate Douglas-fir stocking in the final stand occurred only if the initial alder component was minimal or removed in an early liberation cut.

Newton, Michael, B. A. El-Hassan, and Jaroslav Zavitkowski. 1968. Role of red alder in western Oregon forest succession. In Biology of alder. J. M. Trappe, J. F. Franklin, R. F. Tarrant, and G. M. Hansen, eds., pp. 73-84. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, OR.

Red alder was studied to determine influence on long-term forest succession. Juvenile growth of alder appears responsible for failure of other species, particularly conifers, to maintain positions of dominance. Success of Douglas-fir depends on delay of 4 to 9 years in estabishment of alder, or occurrence of the two species at such a spacing that Douglas-fir will be from 8- to 10-years-old before encroachment by alder.

Common successors to alder include salmonberry, vine maple, and hazel, in that order. Western hemlock may follow eventually, but Douglas-fir is virtually absent except where it develops concurrently with the alder in openings within the alder stand.

Radosevich, S. R., P. C. Passof, and O. A. Leonard. 1976. Douglas-fir release from tanoak and Pacific madrone competition. Weed Sci. 24(1):144-145.

Tanoak and Pacific madrone growing as an overstory to small Douglas-firs were treated by cut-surface methods in April 1964 on an area near Ukiah, California. Herbicides used were the amines of 2,4-D and 2,4,5-T and the potassium salt of picloram. In August 1974, radial cores at breast height were obtained from released Douglas-firs, and tree age and inside bark basal area growth was measured. Growth differences between treated and untreated 232m^2 plots were subjected to a t-test for statistical analysis. Comparisons were made for only Douglas-firs at least 15 years old since younger trees were either nonexistent, very small, or subjected to competition from larger Douglas-firs. Results after 10 years were:

	Basal area	Basal growth
	(cm^2)	(%)
Untreated	7.2	100
2,4-D	18.7	260
2,4,5-T	32.5	451
Picloram	29.2	405

Three trees in the picloram plot died, perhaps as a result of soil activity of the herbicide leaking from treated hardwoods. Intra-species competition among Douglas-firs explains the observed growth differences between 2,4-D and the other herbicide treatments.

Roy, Douglass F. No date. Douglas-fir seed production and dispersal in northwestern California. Unpublished report on file, USDA For. Serv. Pac. Southwest For. and Range Exp. Stn., Redding, CA.

All brush (mostly tanoak and snowbrush ceanothus) was cut from one-fourth of a block of 5-year-old natural Douglas-fir in northwestern California. Brush sprouts were spot treated with herbicide the following year. Thirty released trees were paired with trees of almost exactly the same height growing in the brush. Results 0 (6-year-old trees), 10 (16-year-old trees), and 17 (23-year-old trees) years after release were:

	Average height at year:		
	0	10	17
	(f)	(f)	(f)
Untreated	4.51	14.9	26.0
Released	4.52	21.8	38.4

The difference in average heights between released and unreleased trees has increased significantly each year. After 17 years, the difference was 12.4 ft or 8.3 years of growth for site index 150 and a rotation age of 100 years. If volume growth is reduced by an 8.3-year period, the volume reduction would be 6700 bf per acre. All released trees were classified as vigorous (based on needle complement, needle color, and needle length), but only 56 percent of the trees growing in the brush were vigorous.

-Ponderosa pine

Barrett, James W. 1970. Ponderosa pine saplings respond to control of spacing and understory vegetation. USDA For. Serv. Res. Pap. PNW-106, 16 p. Pac. Northwest For. Exp. and Range Stn., Portland, OR.

_____. 1973. Latest results from the Pringle Falls ponderosa pine spacing study. USDA For. Serv. Res. Note PNW-209, 21 p. Pac. Northwest For. and Range Exp. Stn., Portland, OR.

Six replications each of 0.192-acre plots were thinned to spacings of 6.6, 9.3, 13.2, 18.7, and 26.4 ft in 40- to 70-year-old sapling ponderosa pine that had developed under an old-growth overstory of about 20 trees per acre. Understory vegetation was removed on three of the six replications for each treatment. Tree and vegetation measurements were made every 4 years for 12 years. Results after 12 years were:

		Trees per acre:				
		1000	500	250	125	62
Untreated	- diameter (in)	3.7	4.1	4.9	6.0	6.3
	- ba (sf)	73.7	46.6	32.8	24.7	13.6
	- height (f)	16.5	15.9	17.6	21.0	21.0
	- net yield (cf/A)	654	381	291	241	127
Treated	- diameter (in)	3.7	4.5	5.8	7.3	8.4
	- ba (sf)	74.1	55.7	45.3	36.7	24.1
	- height (f)	15.1	17.0	20.7	25.1	25.0
	- net yield (cf/A)	602	459	426	403	255

Logging old-growth ponderosa pine carefully, thinning the understory saplings, and controlling the brushy understory vegetation appear to have distinct advantages over clearcutting and planting. Possibly 10 years of stand growth may be saved by treating the brush early in the rotation.

Bentley, Jay R., Stanley B. Carpenter, and David A. Blakeman. 1971. Early brush control promotes growth of ponderosa pine planted on bulldozed site. USDA For. Serv. Res. Note PSW-238, 6 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, CA.

Seedling 2-0 ponderosa pine were planted the spring following bulldozing of a dense stand of native brush at Mount Shasta, California. Thirty-five 66x132 ft plots were sprayed the same year or 1 year after planting with various treatments and then 2 years after planting with 4 lb ae per acre 2,4,5-T to control greenleaf manzanita and snowbrush seedlings and sierra plum and bush chinkapin sprouts. On 10 plots, brush was not sprayed.

Brush seedlings did not noticeably affect growth of the small pine seedlings during the first 2 years after planting on the cleanly bulldozed area. After the third season, however, vigor of the pines was obviously reduced by brush competition in the unsprayed plots. Reduced growth of pines in unsprayed plots became more apparent each year. On sprayed plots having an average brush crown volume less than 10,000 cf per acre 5 years after clearing, pines averaged 35-in tall. Pines averaged only 20- to 28-in tall on plots having more than 20,000 cf per acre of brush. The 5-year level of brush control had continuing marked effects on growth of pines during their 7th year. Levels of brush control producing less than 5000 cf of brush per acre at age 5 years were beneficial for growth of young pines. Heights after 5 and 7 years were:

	Brush crown volume index at age 5 (1000 cf/A)				
	2	8	14	24	40
Height at age 5 (in)	34	34	30	26	20
Height at age 7 (in)	62	59	50	40	30

Dahms, Walter G. 1950. The effect of manzanita and snowbrush competition on ponderosa pine reproduction. USDA For. Serv. Res. Note No. 65, 3 p. Pac. Northwest For. and Range Exp. Stn., Portland, OR.

An untreated and an adjacent 66x1000 foot plot were established near Pringle Butte in central Oregon. Manzanita was pulled up by hand, and snowbrush was either grubbed out or chopped off at the ground line on the cleared plot. Development of brush plants and ponderosa pine seedlings was followed on 20 milacre plots along the center line of each strip.

Examination of the plots for 13 years (1934 to 1947) after clearing showed:

	Seedlings established	Average seedling height: Existing seedlings	Average seedling height: New seedlings (after 1934)
	(no)	(f)	(f)
Untreated	39	1.24	0.41
Cleared	26	3.98	0.97

Brush did not significantly affect early establishment of pine seedlings but sharply reduced growth of established seedlings. Manzanita was a more severe competitor than snowbrush--seedlings existing at the time of treatment averaged 1.79-ft tall under snowbrush after 13 years but only 0.78 ft under manzanita.

Fago, Clifford E. 1972. Ponderosa pine growth response on a California Division of Forestry fuelbreak. Calif. Div. For. State For. Notes No. 49, 2 p. Sacramento, CA.

A study was established on a 6-year-old fuelbreak on Boggs Mountain State Forest, Lake County, California, to measure response of ponderosa pine to release from a dense brush understory and pine competition. The fuelbreak contained 4 to 8 ft. high brush, primarily manzanita and dominant pine reproduction 15 ft. high and 4 in. d.b.h. at the time of construction in 1965. All brush in a 75 ft. strip on each side of a road was hand cut in 1965 and brush seedlings and sprouts spot sprayed with 2,4,-D and 2,4,5-T mixture in 1969. Ponderosa pine reproduction was thinned to an average 10 x 10 ft. spacing. Growth of 92 dominant released trees was compared in 1971 with growth of 92 dominant trees growing with dense brush and codominant pine reproduction. Four-tree groups within and outside the fuelbreaks were paired and replicated 23 times in a paired plot design.

Five year diameter growth of released trees was 38 percent greater than diameter growth of control trees adjacent to the fuelbreak (1.8 in. versus 1.3 in.). Five year height growth of released trees was only 1.6 percent higher (8.25 ft. versus 8.05 ft.). Removal of competing vegetation substantially increased ponderosa pine diameter growth but had little effect in height growth in the first 6 years after release. Released trees were noticeably more vigorous with higher live crown to total height ratios than unreleased trees.

McDonald, Philip. 1978. Brushfield ecology and growth of planted pines. Unpublished, data on file. USDA For. Serv. Pac. Southwest For. and Range Exp. Stn., Redding, CA.

An area near Mt. Shasta, California, was cleared with a bulldozer in 1961 and planted with 1-0 ponderosa pine during the spring of 1962. Part of the area was sprayed with various herbicide formulations, dosages, methods of application, and carriers in 1962 and part again in 1964 creating a range of brush densities. In 1966 when the plantation was 4-years-old, four 66x132 plots were established in each of four degrees of brush cover: (1) heavy brush (untreated with herbicides); (2) medium brush; (3) light brush; and (4) almost no brush (1 or 2 sprays). Greenleaf manzanita, snowbrush, ceanothus, and sierra plum dominated the brush plots. Forty trees in each plot were sampled for survival, height, damage, and cause of damage. Results in 1977, 15 years after planting were:

	Height (f)
Heavy brush	5.5
Medium brush	8.4
Light brush	9.4
Brush free	14.6

Oliver, William W. 1979. Early response of ponderosa pine to spacing and brush: observations in a 12-year-old plantation. Manuscript in preparation. On file, USDA Forest Service Pac. Southwest For. and Range Exp. Stn., Redding, CA.

Ponderosa pine 1-0 seedlings were planted at five different spacings from 6x6 to 18x18 ft on an intensively bulldozed clearcut on a highly productive site (site index 110 ft) on the Challenge Experimental Forest in California. Spacing and brush effects were evaluated in two randomized blocks each allowed to develop normally on one half of each plot. The other half was kept free of brush by spraying 2,4,5-T applied by hand sprayer in the second and fourth years after planting. Newly germinated brush seedlings were grubbed out by hand. Each split plot contained 12 measurement trees; the few trees that died were replaced from surplus stock planted adjacent to the experimental site.

Results 14 years after planting were:

Spacing	d.b.h.	Height	Basal area	Stem volume
(f)	(in)	(f)	(f^2/A)	(cf/A)
6x6 with brush	3.3	16	66	421
without brush	3.9	17	90	611
9x9 with brush	4.6	17	64	433
without brush	5.4	21	85	640
12x12 with brush	4.6	17	36	250
without brush	6.4	22	67	519
15x15 with brush	4.2	16	18	120
without brush	6.7	22	48	364
18x18 with brush	5.3	19	21	152
without brush	7.7	24	43	354

Spacing and brush competition emerged as strong influences on stem diameter, crown width, live crown ratio, and average branch diameter 12 years after planting. Tree crown characteristics, especially live crown ratio, were more sensitive to brush competition than were stem characteristics. Brush seeds germinated abundantly and seedlings grew rapidly on plots where they were allowed to develop. But few ponderosa pines were overtopped by brush because: (a) complete site preparation eliminated all exisiting brush and nearly all hardwood sprouts, and (b) the pines grew rapidly in height. However, trees competing with brush grew more slowly than trees free of brush. Diameters of tree stems in brush grew only 76 percent of those found in brush-free plots after 12 years. Plots with a light brush cover of 30 percent lost the equivalent of 1.1 year's diameter growth; on plots with dense cover the loss was equivalent to 2.6 years. Nearly one-fourth the growth potential was lost in these brush-choked plots, despite a productive site, cleared and groomed before planting, and rapid growth which kept the tree crowns above the brush. Brush competition could delay commercial thinning about 6 years.

Oliver, William W. 1979. Early results from a tree spacing--brush density study on the Mendocino National Forest. Memorandum. On file, USDA Forest Service Pac. Southwest For. and Range Exp. Stn., Redding, CA.

A ponderosa pine plantation was established in 1960 in a shallow skeletal soil (site class IV) at 4,000 feet on the Mendocino National Forest in California. A tree spacing-brush density study was installed in 1977 to evaluate the influence of spacing and brush competition on tree growth. The brush density experiment consists of 18 plots divided into thirds. Brush, principally Arctostaphylos canescens was untreated on one-third, half removed by hand on one-third, and totally removed by hand on the remaining third.

Results 2 years after brush removal were:

Brush treatment	Brush crown volume (cf/A)	Brush crown coverage (%)	Periodic annual diameter growth (in)
Full removal	0	0	0.24
Half removal	28,434	15	0.16
No removal	52,712	35	0.12

Powers, Robert F. and Grant D. Jackson. 1978. Ponderosa pine response to fertilization: influence of brush removal and soil type. USDA For. Serv. Res. Pap. PSW-132, 9 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, CA.

An 80-acre area on two contrasting soils (Mariposa and the more productive Cohasset series) was bulldozed in 1966, planted with ponderosa pine in 1967, and sprayed with 2,4,5-T in 1968. By 1975, the tallest trees on the Mariposa series were only half a meter above the brush, but more than a meter above on the Cohasset series. Eighteen 0.1-acre plots were established on each site in July 1975 in a randomized block design with three blocks of six treatments each. Agricultural grade urea was applied at 0, 200, and 400 lb N/acre and combined with removal or nonremoval of competing brush. Brush was removed with hand tools from nine plots in each soil series. An average of 15 trees was measured in each plot. Results one growing season after treatment were:

	Mariposa series		Cohasset series	
	Height growth (cm)	Diameter (cm)	Height growth (cm)	Diameter (cm)
Brush present				
0 lb/A N	12.5	4.5	41.1	8.5
200 lb/A N	15.7	5.0	51.1	9.2
400 lb/A N	14.7	4.7	42.0	9.1
Brush absent				
0 lb/A N	16.5	4.9	45.5	9.3
200 lb/A N	29.8	6.8	52.0	9.6
400 lb/A N	28.1	6.2	43.2	7.9

First year results show that trees testing low in foliar nitrogen (on the Mariposa series) responded strongly to fertilization where brush had been removed, but failed to respond if brush remained. Height growth was doubled by certain treatment combinations on the less fertile Mariposa soil, but was not influenced by treatment on the more fertile Cohasset series. Brush removal increased needle weight for trees on both soils. Increases in foliar biomass and nitrogen content of trees on treated plots suggest that rapid growth rates will continue.

-Western conifers

Baron, Frank J., N. Stark, and Gilbert H. Schubert. 1964. Effects of season and rate of application of 2,4-D and 2,4,5-T in pine seedlings and mountain whitethorn in California. J. For. 62(7):472-474.

Intermingled sugar and ponderosa pine and mountain whitethorn on the Stanislaus-Tuolumne Experimental Forest near Sonora, California were treated with foliage sprays of 2,4-D or 2,4,5-T to test season of application, concentration applied to individual pines growing in brush, and spray dosage applied on an area basis. Five trees each were treated with 200 ppm of 2,4-D and 2,4,5-T at monthly intervals between April and September. Growth of treated sugar pines was compared with 10 untreated trees and 10 trees released by mechanically removing the brush and root crowns. Five trees each were treated with 50, 100, 200, 400, and 600 ppm of 2,4-D or 2,4,5-T in September in the concentration study. Ten unsprayed tree-brush clumps served as controls. Finally, six 1/10-acre plots were sprayed with 2,4,5-T at 0, 1/4, 1/2, 1, 2, and 4 lb in 50 gal of water per acre. The 2,4-D treatments were less effective on mountain whitethorn and severely damaged the intermingled pines. Sprays containing 2,4,5-T applied before August or at concentrations above 200 ppm were also damaging. Results 2 or 3 years after spraying the most effective treatments were:

	Sugar pine 3 y height growth (% of control)
Untreated	100
2,4,5-T:	
100 ppm September	105
200 ppm August	113
200 ppm September	143
Mechanical	100

2,4,5-T application rate (lb/A)	Sugar pine 2 y height growth (% of original)	Sugar pine survival (% of original)	Ponderosa pine 2 y height growth (% of original)	Ponderosa pine survival (% of original)
0	29	100	28	100
1/4	33	100	48	100
1/2	33	97	31	100
1	37	96	--	--

Sugar pine height growth exceeded that of the untreated controls following an August or September application of 2,4,5-T. Pines released with 2,4,5-T in September also grew more rapidly than trees released mechanically. Height growth of sugar pines also increased following broadcast sprays of 2,4,5-T at dosages up to 1 lb per acre.

Hawkes, Carl. 1953. Planes release tree plantation. J. For. 51(5):345-348.

Hawkes, Carl. 1950. A report on plantation release. Blodgett Tract, Siuslaw National Forest. Unpublished report. On file, Siuslaw National Forest, Corvallis, Oregon. November 10, 1950. 26 p.

Between 1948 and 1951, experiments to compare cutting and girdling with sprays or dusts of 2,4-D to release 2 to 8 ft tall planted Sitka spruce, Douglas-fir, and Port-Orford-cedar from 10 to 20 ft tall red alder were installed on the Siuslaw National Forest between Waldport and Yachats, Oregon. Results from the first tests conducted on about 120 acres during the winter and spring of 1948 showed that mechanical treatments were effective but spraying with 2,4-D from an airplane was the most satisfactory and least expensive. Height growth of released and unreleased trees from the 2 years immediately before and after release spraying was:

		Height growth for 2 years	
		Before release	After release
		(in)	
Sitka spruce	--not released	21	11
	--released	21	33
Douglas-fir	--not released	21	10
	--released	21	40
Port-Orford-cedar	--not released	8	14
	--released	8	17

The growth of all three species increased following release spraying despite some herbicidal damage to exposed trees. Douglas-fir saplings grew twice as fast after release and four times the rate of trees still under the red alder. Over 60 percent of the Douglas-firs under the alder had lost their leaders at some time, initially from rodents and deer and recently from being whipped by alder branches.

Ruth, Robert H. 1956. Plantation survival and growth in two brush-threat areas in coastal Oregon. USDA For. Serv. Res. Pap. No. 17, 14 p. Pac. Northwest For. and Range Exp. Stn., Portland, OR.

Plantation development was followed on a 44-acre clearcut planted with 3-0 Douglas-fir near Florence, Oregon, and an 88 acre clearcut planted with 3-0 Sitka spruce, western hemlock, Douglas-fir, and Port-Orford-cedar in four plots each on burned and unburned areas near Otis, Oregon. The effect of five levels of shade from competing brush on seedling survival was studied on both plantations. The results after 5 years were:

	Douglas-fir plantation at Florence		Mixed plantation at Otis	
	Average annual height growth (in)	Survival (%)	Average annual height growth (in)	Survival (%)
Not shaded	25.0	100	27.0	100
1/4 shaded	24.6	100	23.0	100
1/2 shaded	18.2	100	18.0	97
3/4 shaded	17.0	100	16.0	100
Overtopped	8.0	89	6.0	86

Competition between planted trees and herbs, shrubs, and alder was intense. Although conifers continued to live under as much as three-fourths shading by competing vegetation, height growth was greatly retarded. Once trees are overtopped by brush, their chances for ultimate survival are negligible, unless released.

Ruth, Robert H. 1957. Ten-year history of an Oregon coastal plantation. USDA For. Serv. Res. Pap. No. 21, 15 p. Pac. Northwest For. and Range Exp. Stn., Portland, OR.

A test plantation of 1,200 2-0 seedlings each of Douglas-fir, Sitka spruce, and Port-Orford-cedar was established in a clearcut near Waldport, Oregon. Annual mortality by shade class during the first 10 years was:

Growing season	Annual mortality by shade class			
	Not shaded	Side shade	Partly overtopped	Fully overtopped
		(%)		
1st	10	11	9	17
2nd	7	4	6	17
3rd	5	4	8	10
4th and 5th	0	2	3	7
6th and 10th	1	1	2	5
Weighted Average	2.7	2.8	3.9	8.3

The study indicates that planted trees could tolerate side shade and some top shade but did not survive long when overtopped.

Zavitkowski, J., Michael Newton, and Babiker El-Hassan. 1969. Effects of snowbrush on growth of some conifers. J. For. 67(4): 242-246.

Douglas-fir seedlings planted in snowbrush ceanothus stands 0- to 15-years-old survived and developed significantly better than ponderosa pine, western hemlock, and noble fir under the same site conditions. Capacity of all four species to dominate the site was greatest in snowbrush at age 0, decreasing with increasing age of the snowbrush. Snowbrush attains full occupancy of the site in about 10 years, causing severe suppression after than time. Growth in height of six naturally developing conifer species was reduced by one-half under suppression by snowbrush. Findings indicate that snowbrush is more detrimental than beneficial on forest regeneration on west slopes of the Oregon Cascades.

ROCKY MOUNTAINS - Ponderosa Pine

Hall, Dale O. and James D. Curtis. 1970. Planting method affects height growth of ponderosa pine in central Idaho. USDA For. Ser. Res. Note INT-125, 8 p. Intermountain For. and Range Exp. Stn., Ogden, Utah.

A 5-year planting test that incorporated three site preparations and three nursery stock handling methods was initiated in the 1931 Quartzburg burn near Idaho City, Idaho, on the Boise National Forest in 1954. Planting sites, three 8-foot-wide lanes, were contoured around the slopes. A D-7 tractor was used to strip dense brush, dominated by snowbrush ceanothus, from two of the lanes. Two furrows made by Talledega plows were added to one lane and the third was left in its natural state; i.e., no brush was removed before planting. Three nursery stock classes were compared: 2-1 stock transported by common carrier and planted by the slit method; 2-1 "special" transported by Forest Service truck and planted by the dug-hole method; and 2-0 "special" handled like the 2-1 "special" stock.

Nine treatment combinations were compared and randomly assigned to nine parallel lines. About 90 acres were planted each spring from 1954 to 1958. Two aspects, easterly and westerly, were sampled in each of the five annual plantings. The entire aspect was systematically sampled by measuring 15 trees on each lane.

In every case but one, careful planting and handling resulted in increased growth each period, regardless of site preparation. No stock treatment nor site preparation method affected survival and height more than brush removal. Five years after planting, survival in brush was 42 percent or less, survival on stripped rows exceeded 71 percent. Ten years after planting, mean seedling heights were:

	Height (ft)
No site preparation	3.18
Stripped	5.06
Stripped and furrowed	5.05

The results suggest that the influence of brush competition on ponderosa pine seedlings is similar to the height-retarding influence of overstocking as described by Lynch (D.W. Lynch. 1958. USDA For. Serv. Res. Paper 56, 36 p. Intermountain For. and Range Exp. Stn., Ogden, Utah.)

Table 1
Response of Douglas-fir to release from
snowbrush ceanothus

Five year diameter and height growth [a/]

Height when released:	2f		4f		6f		8f		10f	
	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)
None	8.1	2.5	15.5	3.6	23.0	4.8	30.4	5.9	37.9	7.0
Lopped	14.1	2.9	21.3	4.0	28.5	5.1	35.7	--	43.0	7.3
Basal sprayed	20.9	3.5	26.1	4.3	31.3	5.2	36.5	6.0	41.6	6.8
Complete release	25.2	3.6	30.1	4.6	35.0	5.6	39.9	6.7	44.8	7.7

[a/] Height growth is based on a regression.

Results after 10 years for the one study area were:

Ten year diameter and height growth

Height when released:	2f		4f		6f		8f		10f	
	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)	dia. (mm)	hgt. (f)
None	35.2	5.4	50.1	9.5	64.9	13.6	79.8	17.7	94.6	21.8
Lopped	54.6	9.0	68.1	13.3	81.7	17.5	95.3	21.8	108.7	26.0
Basal spray	63.5	10.1	71.1	14.5	78.7	18.9	86.3	23.3	93.9	27.7
Completed release	74.7	14.9	87.1	18.1	99.5	21.2	112.0	24.4	124.4	27.6

Understory trees of all species benefited from removal of overstory trees regardless of method, season, or degree of release. Survival of pines was reduced by clearcutting the overstory (complete release) because treatment was delayed 1 year after planting. The most obvious result was that the growth rate of trees of all species consistently increased with amount of overstory reduction. For reproduction as a whole, survival was directly related to extent of overstory removal. However, survival of pines was not greatly increased by release.

Average height growth of pine reproduction during the 11 years after release was:

	Height growth (f)			
	Overstory basal area in square feet			
	0	27	54	79
Seedlings	10.2	4.3	1.9	1.5
Sprouts (only 25 trees/A)	14.5	17.8	---	4.3
Planted	17.1	8.5	4.3	3.5
All	15.0	6.2	3.1	3.1

Height growth was independent of method or season of release but markedly influenced by degree of release.

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